FERTILISER MANAGEMENT IN CASSAVA - GROUNDNUT INTERCROPPING SYSTEM

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Fertiliser management in cassava-groundnut intercropping system" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any University or Society.

Vellanikkara, (T.K. BRIDGIT)

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CERTIFICATE

Certified that this thesis entitled "Fertiliser management in cassava-groundnut intercropping system" is a record of research work done independently by Smt. T.K. Bridgit, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

Population explosion demands a food production revolution and of late, intercropping has been suggested as a viable agronomic alternative to improve the intensity of cropping and productivity of land. Many such intercropping systems were developed, evaluated and recommended (Singh and Mandal, 1968; Sintuprama, 1976; Chew, 1978 and Mohankumar and Hrishi, 1974). Cassava is the most important subsidiary food crop of Kerala. Attempts to increase the intensity of cropping in cassava by exploiting the interspaces during the early phase of growth by growing some fast growing short duration, short statured crops were made (Nambiar et al., 1979; ICRISAT, 1979 and Thomas and Nair, 1979).

Fertiliser management in such high intensity crop production systems is of vital importance and the present practice of transducing the sole crop fertiliser management to suit intercropping situation without much field trials may hamper the full exploitation of productivity of the cropping system as a whole.

Considering the fact that cassava is a soil exhaustive crop and its nutrient demand is high, the same must be given at the optimum time of the crop requirement. When intercrops are grown top dressing to cassava can be done only after the harvest of the intercrop beyond three months after planting. Experiment conducted at Agricultural College, Vellayani, indicated the beneficial effect of three split application of N and K fertilisers (Ashokan and Sreedharan, 1977). Further studies at Vellayani confirmed the better performance of three split application of basal, two months and three months after planting (Nair, V.M. 1982). However, experiments to evaluate the efficiency of N and K fertiliser beyond three months are rare.

Trials conducted at Vellanikkara emphasized that skipping the basal dose and applying N and K at 15 DAP was better than basal application of fertilisers (Ashokan and Nair, 1982). This is persumably due to the leaching loss of nutrients taking place before the establishment of the crop. Skipping the basal dose of N and K may prove to be beneficial under heavy rainfall situations. This aspect also has to be investigated in detail.

The beneficial effect of leguminous intercropping in terms of increasing the fertility of soil has been fairly well established (ICRISAT, 1981). However, the contribution of N to main crop from the associated legume intercrop has not been fully assessed. Eventhough cassava - groundnut intercropping system is recommended for large scale adoption in Kerala, the complementary effect of groundnut on the cassava crop has not been fully investigated under Kerala conditions.

It has been reported that intercropping groundnut with cassava is profitable (Singh and Mandal, 1968). The productivity of intercropping system will be higher than that of the respective sole crop. This has been amply demonstrated in other crops (ICRISAT, 1981). However, such studies are rare in cassava - groundnut intercropping system. So it has become necessary to take up the present investigation with the following objectives.

1. To evaluate the efficiency of split application of N and K beyond three months.
2. To find out the effect of skipping the basal dose of N and K fertilisers.
3. To assess the saving of fertiliser nitrogen in the intercropping system.
4. To study the productivity of cassava - groundnut intercropping system.

Review of Literature

REVIEW OF LITERATURE

An experiment was conducted with the object of studying the effect of levels of N and time of application of N and K in a cassava - groundnut intercropping system. Available literature on the effect of N and K and their time of application on the growth, yield, quality and economics of sole and intercropped cassava are reviewed in this chapter. Wherever sufficient literature was not available in a cassava - groundnut intercropping system, literature from other crops are also mentioned.

2. Effect of N and K on growth attributes and yield

2.1. Effect of N

Higher levels of nitrogen invariably favoured the vegetative growth of the plant. Ramanujam and Indira (1979) reported that the rate of leaf production was high under higher levels of N and would produce about 10 to 12 leaves per plant per week. Similar increase in leaf production with incremental dose of nitrogen was noticed by Prabhakar et al. (1979). Krochmal and Samuels (1970) and Cheo-Samut (1974) reported that N application increased weight of stem and leaves, total dry weight of plant, top root ratio and plant height. Pillai and George (1978) also reported the favourable effect of higher levels of N on plant height. Ngongi (1976) got more LAI and leaf area duration with N dressing.

Degues (1967) reported that higher levels of N increased the number of tubers per plant. Similar results have been reported by Vijayan and Aiyer (1969). Pillai and George (1978) also observed that the number of tubers per plant was more at higher levels of N.

Nitrogen is one of the important nutrients required for increased tuber production in cassava. Significant response to N application has been observed in cassava in different soils and climatic conditions (Chanda, 1958; Pillai, 1967; Ofori, 1976; Takyi, 1974; Prabhakar et al. 1979 and Ramanujam, 1982). Obigbesan and Fayemi (1976) obtained maximum tuber yield in improved varieties with 120 kg N per hectare. Dharmaputra and Bruijn (1976) observed a significant increase in tuber yield upto 100 kg N per hectare. Experiment conducted at Agricultural College, Vellayani showed that application of 100 kg N, 50 kg P and 150 kg K was most promising for maximum tuber production in cassava variety M_4 (Pillai and George, 1978). Reports from CTCRI showed that the most economic level of N for maximum tuber production in hybrids was 80 kg and for local variety 40 kg per hectare (Mohankumar and Mandal, 1977).

From the review given above, it could be seen that higher levels of nitrogen enhanced plant growth and tuber yield. However, the optimum dose was found to vary with locations and varieties.

Time of application of N

Reports from CTCRI (1978) indicated that cassava was benefitted by N application even at 150th DAP. The importance of skipping the basal dose of N and applying it in two splits at the time of sprout emergence and two months after planting has been highlighted in the studies conducted at Kerala Agricultural University (KAU, 1981). Gomes et al. (1981) also observed an increase in tuber yield with delayed application of N upto 150 DAP. Ashokan and Nair (1982) reported that application of N in three equal split doses, 15th, 60th and 90th DAP was beneficial in achieving higher tuber yield of cassava. However, Correa et al. (1981) could not obtain any significant difference in yield by split application of nitrogen.

From the above review it is seen that split application of N at different stages of growth was beneficial for better growth and yield of cassava. However, effect of skipping the basal dose of N and application of N beyond three months was not studied in detail.

2.2. Effect of K

In general the morphological growth characters of cassava were found to be benefitted by K. Application of 200 kg K ha^{-1} increased the height of plant as compared to 100 kg ha^{-1}, but the number of leaves per plant decreased (Pillai, 1967). Natarajan (1975) observed that 150 kg K ha^{-1} was significantly superior to the lower levels of 50 and 100 kg in increasing the height of plant and number of leaves per plant.

Malavolta et al. (1955) in their studies on mineral nutrition of cassava observed that in the absence of K weight of root was decreased whereas that of shoot increased. However, Pushpadas and Aiyer (1976) did not get any effect for K on the shoot weight at harvest.

Application of 150 to 200 kg of K increased the mean girth of tuber over 100 kg level (Pillai, 1967). Ofori (1976) observed that the tuber number and weight were enhanced by K application. Natarajan (1975) also reported higher number of tubers per plant by increased K application from 50 to 150 kg ha^{-1}.

Response to K application in cassava has been studied extensively and several authors have reported increase in tuber yield upto 100 kg ha^{-1}; beyond this level the yield decreased (CTCRI, 1978;

Samuels, 1969; Mandal and Singh 1970; Kumar et al., 1971 and Mohankumar and Nrishi, 1973). Raising the level of K from 37.5 to 112.5 kg ha^{-1} increased tuber yield from 24 to 39.1 t ha^{-1} (Ashokan and Sreedharan, 1977). In Columbia a significant maximum response was obtained at 120 kg ha^{-1} of K (CIAT, 1975). Chan and Lee (1982) recorded maximum tuber yield at 180 kg ha^{-1} of K. Muthuswamy and Rao (1983) estimated optimum dose of K as 260 kg ha^{-1} to produce an yield of 43 tonnes ha^{-1}.

Time of application of K

There is considerable ambiguity over the time of application of K giving widely varying results.

Mohankumar (1968) reported that available K in the soil was increased by split application of K at one and two months after planting. Mandal et al. (1968) observed that split application of K, half as basal and the other half one month after planting, recorded the highest yield of 25.2 tonnes ha^{-1} of tuber compared to 22.8 tonnes ha^{-1} for single basal application.

Mandal and Singh (1970) found that half K given one month after planting and the other half two months after planting gave a significantly higher yield than half as basal and the other half two months after planting.

Kumar et al. (1971) could see that application of 100 kg level of K given in two split doses of half as basal and the other half two months after planting gave the highest yield than the K applied either as single dose as basal, one or two months after planting or in two equal split doses of one month and two months after planting.

Ashokan and Sreedharan (1977) reported that three split applications of K, 1/3 as basal, 1/3 60 DAP and 1/3 90 DAP gave better results with lower levels of K (75 kg/ha) whereas at higher levels (112.5 kg ha^{-1}) two split application of half as basal and the other half 60 DAP was better. For reducing nutrient losses in heavy rainfall areas and to increase tuber yields Ashokan and Nair (1982) advocated three split applications at 15^{th}, 60^{th} and 90^{th} DAP. However, Nunes et al. (1974), Correa et al. (1981) and Wahab and Luyo-Lopez (1981) found that split application of K did not influence tuber yield and dry matter production.

From the review on time of application of K it is seen that the split application of K is beneficial for cassava. However, the time of the split application has not been clearly specified. It is also seen that trials with skipping the basal dose of K and application of K after three months were rare.

2.3. Effect of intercropping on growth and yield of cassava

The practice of intercropping in cassava has been reported from Brazil as early as 1935 (Marcus, 1935). Reports from various parts of the world revealed that intercropping Cassava with leguminous plants was successful.

Singh and Mandal (1968) reported that growing groundnut as intercrop in cassava did not substantially affect the growth and yield of cassava. Bhat (1978) also reported that the top and tuber yield were not affected by growing groundnut, cowpea, black gram and green gram as intercrops. Similar results were obtained by growing groundnut and cowpea as intercrops in cassava (Katyal and Dutta, 1976; Sintuprama, 1976 and Sheela, 1982).

In Malaysia groundnut showed great potential as an intercrop in cassava without affecting the tuber yield (Chew, 1978). Mohankumar (1975) reported that bunch variety of groundnut could be taken as a successful intercrop in cassava. Studies conducted at CTCRI, Trivandrum have shown groundnut as a suitable intercrop for cassava (Mohankumar and Hrishi, 1974). An increase in tuber yield of cassava by 0.49 t ha^{-1} was reported by Thomas and Nair (1979) when it was intercropped with groundnut. Sheela (1982) reported that groundnut was found to be the best suited intercrop for cassava.

On a perusal of the review given above it could be seen that tuber yield of cassava was considerably increased by legume intercropping. Among the intercrops groundnut seems to be the most suitable intercrop in cassava. However, reduction in tuber yield of cassava by intercropping was also seen in several cases.

2.4. Fertiliser application in an intercropping system of cassava

The results of the trials conducted at various places indicated that intercrops responded well to the application of fertilisers. The following observations revealed that the main crop and intercrop should be fertilised for better results.

Mohankumar and Hrishi (1974) found that application of fertilisers to both the main crop and intercrops like cowpea, sunflower, green gram, black gram and groundnut produced higher yield which was significantly superior to application of fertilisers to main crop only. Mohankumar (1975) also reported the beneficial effect of fertiliser application to main crop and intercrop.

From the experiment conducted at CIAT it was found that groundnut in association with cassava produced pod yield of 1.5 tonnes per hectare with a fertiliser level of 100, 105, 35, 3 and 3 kg ha^{-1} respectively of N, P_2O_5, K_2O, Zn and Bo and 0.5 t ha^{-1} lime (CIAT, 1976). It was also reported that small amounts of nitrogen appeared to be optimal both for cassava tuber production and grain legume production.

In an experiment on intercropping cassava with groundnut and pulses at Agricultural College, Vellayani. Bhat (1978) concluded that intercrop should be fertilised seperately in addition to the fertilisation of main crop of cassava. He worked out the optimum dose of N,P and K for groundnut when grown as intercrop with cassava as 18.03:27.05:36.06 kg ha^{-1}.

Sheela (1982) reported that intercropping cassava with groundnut was remunerative than pure cropping. She also reported that for cassava - groundnut intercropping system, the fertility level of 93.75:75.00:93.75 kg N,P,K ha^{-1} was found to be most profitable and this gave an additional income of 4667.71 Rupees per hectare over the pure crop system.

From the review cited above it may be seen that application of fertilisers both to the main crop and intercrop was beneficial for better production. However, trials on quantity and time of application of fertilisers particularly N and K for a cassava - groundnut intercropping system were not generally seen conducted.

2.5. Effect of N,K and intercropping on quality attributes of cassava.

2.5.1. Drymatter content of tuber

Pillai (1967) observed an increase in drymatter content of tuber due to nitrogen fertilisation. Vijayan and Aiyer (1969) also observed increase in drymatter content upto 75 kg N per hectare and a decrease with further increase in N to 150 kg N per hectare. Similarly Mandal et al. (1971) observed an increase in dry matter content of tuber from 29.6 per cent in the control to 31.5 per cent at 100 kg N per hectare and a further increase in N from 150 to 200 kg per hectare decreased the same to 30.7 and 29.9 per cent respectively.

Obigbesan (1973) reported that high level of K application considerably improved the drymatter content of cassava tuber. Ashokan and Sreedharan (1978) also reported that increased K application increased the dry matter content of edible portion of tubers.

Bhat (1978) reported that intercropping of groundnut recorded the highest drymatter content of cassava tubers. He noticed a further increase in drymatter content of cassava by fertilising the intercrop. Similarly Sheela (1982) reported that drymatter content of cassava was influenced by intercropping with groundnut. She also reported that among intercrops groundnut recorded higher drymatter content of tubers than cowpea.

2.5.2. Starch content

Ramanathan et al. (1981) reported that application of 80 to 120 kg N per hectare along with 40 to 80 kg K per hectare significantly increased the starch content of cassava tubers. Muthuswamy and Rao (1983) reported that the starch content of tuber was not influenced by application of higher levels of N upto 150 kg per hectare. Similarly Indira and Sinha (1983) also reported that higher levels of N did not affect starch content significantly. However several workers showed that higher levels of nitrogen significantly decreased the starch content of cassava tuber (Malavolta, 1955; Vijayan and Aiyer, 1969 and Prema et al., 1975).

Mandal et al. (1968) and Kumar et al. (1971) reported the beneficial effect on starch content due to split application of K. Increase in starch content of cassava tuber with increasing levels of K has been reported by Obigbesan (1973) and Ashokan and Sreedharan (1977).

Bhat (1978) noted an increase in starch content of cassava tuber when grown in association with groundnut, cowpea, blackgram and green gram. Among the intercrops groundnut and cowpea were found to have maximum effect. He also reported that application of fertilisers to the intercrop increased the starch content of cassava tubers and groundnut gave higher starch percentage of cassava tuber than cowpea intercrop.

2.5.3. Crude protein content

Several workers have reported enhanced crude protein content of cassava tuber with increased N levels (Malavolta, et al. 1955; Pillai, 1967; Pillai and George, 1978). Gomes and Howler (1980) and Muthuswamy and Rao (1983) also obtained similar results.

A significant reduction in crude protein content of cassava tuber due to higher levels of K was observed by several workers (Pillai, 1967; Natarajan, 1975; Pushpadas and Aiyer, 1976; Ashokan and Sreedharan (1977) and Ramanathan et al. 1981). However, Ashokan and Sreedharan (1977) could not get significant difference in crude protein content with split application of K.

A higher crude protein content of cassava tubers by legume intercropping was recorded by Bhat (1978). Among the intercrops groundnut contributed to the highest increase in crude protein content in cassava tuber. Sheela (1982) also reported that intercropping cassava with legume increased the crude protein content of Cassava tubers and among intercrops cowpea gave a significant increase in crude protein content than groundnut intercrop.

2.5.4. Hydrocyanic acid content

Application of nitrogen alone or in combination with P increased HCN content of tubers significantly (Pillai, 1967; Sinha and Indira, 1968 and Kumar et al. 1971). Prema et al. (1975) also reported that higher levels of N significantly increased the HCN content of tuber.

Unlike N, K application helped in reducing the HCN content of cassava. Increasing levels of K significantly reduced the HCN content of tubers (Bruijn, 1971; Obigbesan, 1973; Natarajan, 1975; Pushpadas and Aiyer, 1976 and Ashokan and Sreedharan, 1977).

2.6. Effect of N application on uptake and distribution of N and K

Rajendran et al. (1976) found that the uptake of K was positively correlated with the rate of N application. They also reported that uptake of both N and K was positively correlated with the cassava tuber yield.

Kanapathy (1974) studied the distribution pattern of nutrients among different parts of the cassava plant. He concluded that N was almost equally distributed in tuber, stem and leaf. The rest of the nutrients P,K,Mn and Fe were largely accumulated in the stem.

Muthuswamy (1978) also reported that N was distributed more or less equally in all the parts. More than 50 per cent of P and K were mobilised to the tuber whereas stem retained a major portion of the absorbed N,Mn and Cu. The leaf blade collected from the top of the plant was found to contain highest N concentration at the 5th month stage and was connected with final tuber yield.

Okeke et al. (1979) reported that per cent nitrogen in various plant parts increased with increasing rates of applied N and P. Potash content in blade and stem appeared to decrease with increasing amounts of N but petiole K showed a linear positive response to applied K. N content in leaf blade at three months stage was well correlated with whole plant dry weight at three months stage and final tuber yield.

2.7. Effect of intercropping on nutrient uptake by main crop

Sheela (1982) reported that nutrient uptake by cassava was enhanced by intercropping with groundnut and cowpea. Cassava-cowpea system recorded higher uptake of N by cassava than cassava-groundnut system.

The highest uptake of potassium was recorded by intercropping at levels of N 75 and P and K each at 112.5 kg per hectare.

Legume intercropping also enhanced the nutrient uptake in other crops. Sharma et al. (1979) reported that nutrient uptake in maize was enhanced by intercropping with legumes and was more in Maize-legume intercropping system than maize sole crop.

Chandrasekar (1978) observed that nutrient uptake in sunflower was reduced by intercropping and among intercrops, groundnut showed maximum reduction in yield. Ravichandran and Palaniappan (1979) reported that legume intercropping did not influence nutrient uptake in sorghum. Singh and Prithamchand (1982) opined that intercropping did not affect N uptake by maize crop at various stages of growth, but N level had a significant influence on N uptake.

2.8. Effect of intercropping on fertility status of the soil

Groundnut and cowpea as intercrops with cassava enriched the soil fertility by adding nitrogen through the organic matter supplied to the soil (Singh et al. 1969). Bhat (1978) observed that the soil fertility was improved by intercropping cassava with legume.

Sheela (1982) concluded that cassava-groundnut intercropping system significantly increased the total nitrogen content of soil than cassava-cowpea system.

Misra (1958) reported that blackgram was grown as intercrop in various places to improve soil fertility. It was also grown as intercrop with other crops in Damodar valley area to reduce soil loss. Jain and Jain (1971) got the beneficial effect of cowpea as an intercrop with maize in reducing loss of soil, water, nitrogen and phosphorus. Lakshminarayana and Reddy (1972) showed that growing groundnut in slopes with shallow rooted and low water requiring short duration crops like jowar or bajra helped to cover the soil and prevent run off. Morachan et al. (1977) found a slight increase in total and available N content of soil due to legume intercropping. Viswambharan (1980) also reported that groundnut intercropping could significantly reduce the run off and soil loss from slopy areas.

From the review cited above it could be seen that intercropping with legume have improved the fertility status of the soil especially with reference to N.

Materials and Methods

MATERIALS AND METHODS

A field experiment was conducted during 1983-84 to study the effect of levels of N and time of application of N and K on cassava-groundnut intercropping system. The details of materials and methods used for this investigation are given below:

3.1. Experimental site

The experiment was carried out at the Agricultural Research Station, Mannuthy.

3.1.1. Soil

The soil of the experimental area was sandy clay loam. The analysis of the soil before starting the experiment is given below:

Mechanical analysis

Mechanical composition of the soil determined by the international pipette method (Piper, 1950) is as follows:

Coarse sand (%)	-	28.85
Fine sand (%)	-	33.28
Silt (%)	-	13.01
Clay (%)	-	23.24
Textural class	-	Sandy clay loam

Chemical analysis

Character	Value	Method used
Soil reaction (pH)	5.2	Soil water suspension of 1:2.5 (Hesse, 1971)
Available N (kg ha^{-1})	573	Alkaline permanganate Method (Subbiah and Asija, 1956)
Total N (%)	0.092	Modified Micro-kjeldahl method (Jackson, 1973)
Available P (kg ha^{-1})	70	Chlorostannous reduced molybdophosphoric blue colour method in Hydrochloric acid system (Jackson, 1973)
Available K (kg ha^{-1})	495	Flame photometry. Neutral normal ammonium acetate extraction (Jackson, 1973)

As per the soil test values the available N,P and K status of the soil was high.

3.2. Season

The experiment was conducted during July ,, 1983 to April, 1984. The crops raised were rainfed.

3.2. Weather conditions

The maximum and minimum temperature, rainfall and relative humidity during the entire crop season recorded at the meteorological observatory of the District Agricultural

Farm, Mannuthy, are presented as weekly averages in Appendix I.

3.4. Materials

3.4.1. Planting material

(a) Cassava

The variety used was M-4, an introduction from Malaysia. It is a tall growing, non-branching variety with moderate yield and maturing in 10 months. It produces medium sized tubers of low HCN content.

(b) Groundnut

TMV-2, a short duration high yielding bunch variety released from Tindivanum was used. It is a photoinsensitive variety of 100 to 110 days duration.

3.4.2. Manures and fertilisers

Urea, superphosphate and muriate of potash containing 45.8% N, 16% P_2O_5 and 60% K_2O respectively were used as the sources of N,P and K nutrients.

3.5. Methods

3.5.1. Treatments

Factorial combination of two cropping systems, two levels of nitrogen and four times of application of N and K was adopted.

(a) Cropping systems (S)

S_0 - Cassava sole

S_1 - Cassava + groundnut

(b) Levels of nitrogen (N)

N_1 - 75% of the recommended dose

N_2 - 100% of the recommended dose (75 kg ha^{-1})

(c) Time of application of N and K (T)

T_1 - No basal + 1/3 15 DAP* + 1/3 60 DAP + 1/3 90 DAP

T_2 - No basal + 1/3 30 DAP + 1/3 60 DAP + 1/3 90 DAP

T_3 - No basal + 1/3 15 DAP + 1/3 75 DAP + 1/3 120 DAP

T_4 - Control i.e. 1/3 basal + 1/3 60 DAP + 1/3 90 DAP (Present Package recommendation)

* DAP - Days after planting

Treatment combinations

1. $S_0N_1T_1$	5. $S_0N_2T_1$	9. $S_1N_1T_1$	13. $S_1N_2T_1$
2. $S_0N_1T_2$	6. $S_0N_2T_2$	10. $S_1N_1T_2$	14. $S_1N_2T_2$
3. $S_0N_1T_3$	7. $S_0N_2T_3$	11. $S_1N_1T_3$	15. $S_1N_2T_3$
4. $S_0N_1T_4$	8. $S_0N_2T_4$	12. $S_1N_1T_4$	16. $S_1N_2T_4$

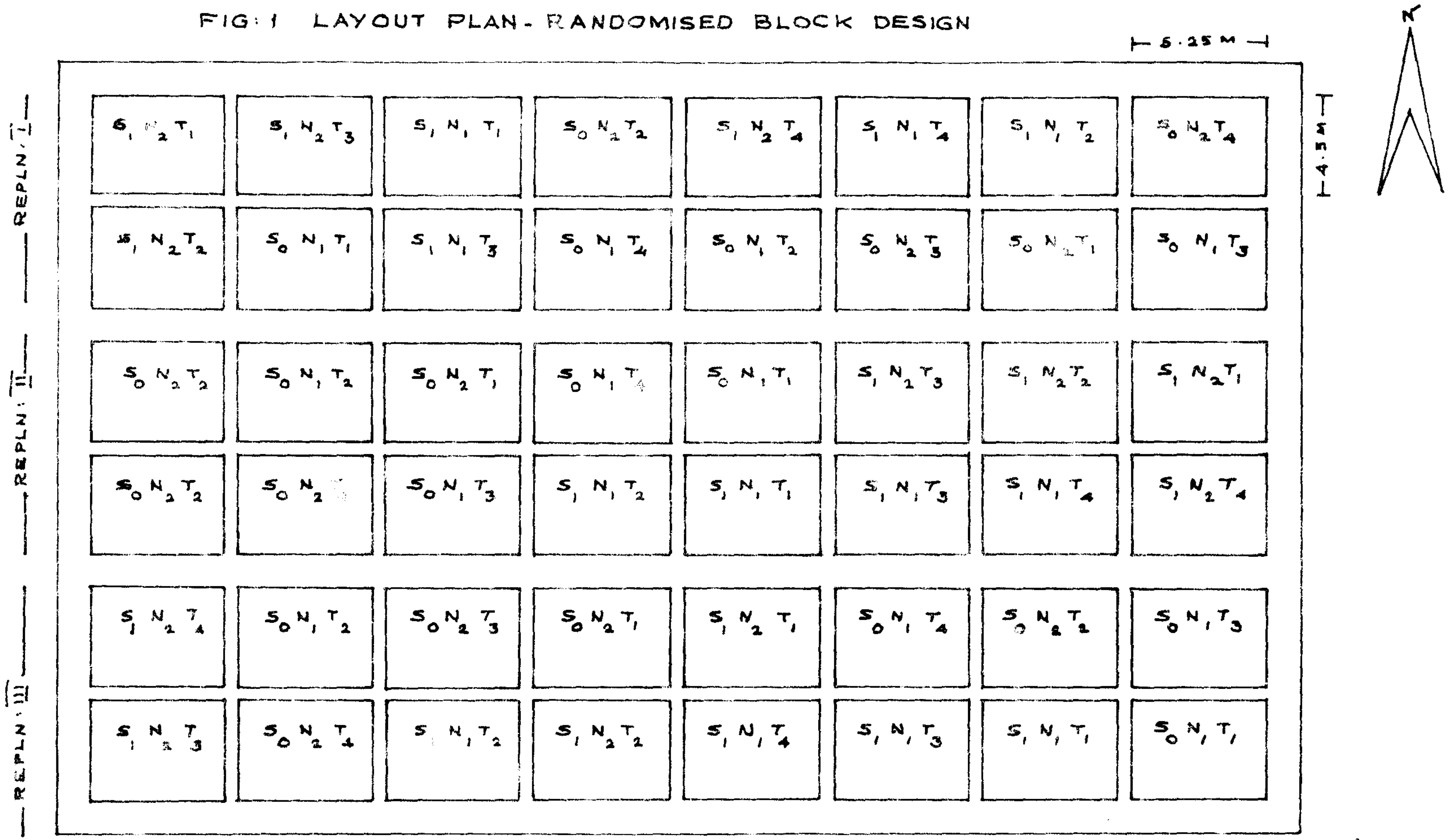
3.5.2. Lay out and design

The factorial experiment was laid out in Randomised Block Design with three replications. The lay out plan of the experiment is shown in Fig. 1.

3.5.3. Spacing and plot size

A spacing of 75 cm x 75 cm was given on both ways for cassava. The gross plot size was 5.25 m x 4.5 m and net plot size 3.75 m x 1.5 m, thus leaving a strip of 3.75 m x 1.5 m for sampling from which plants were

FIG: 1 LAYOUT PLAN - RANDOMISED BLOCK DESIGN



CROPPING SYSTEMS

S_1 – CASSAVA + GROUNDNUT

S_0 – CASSAVA SOLE CROP

LEVELS OF NITROGEN

N_1 – 56.25 Kg ha^{-1}

N_2 – 75 Kg ha^{-1}

TIME OF APPLICATION

T_1 – 1/3 15 DAP + 1/3 60 DAP + 1/3 90 DAP

T_2 – 1/3 30 DAP + 1/3 60 DAP + 1/3 90 DAP

T_3 – 1/3 15 DAP + 1/3 75 DAP + 1/3 120 DAP

T_4 – 1/3 BASAL + 1/3 60 DAP + 1/3 90 DAP uprooted periodically for determining leaf area and for chemical analysis.

3.5.4. Field culture

The package of practices recommended by KAU (1982) was followed for the cultivation of the crops.

Land preparation

The experimental area was dug once and cleared of weeds. The field was laid out into plots and grouped into three blocks as per the design. Mounds were formed at a distance of 75 cm on both ways.

Manuring

A uniform dose of 12.5 t ha^{-1} of FYM was applied and incorporated into the soil before taking mounds.

Fertiliser application

Full dose of P (75 kg ha^{-1}) was applied as basal for cassava. N and K were applied as per the treatments. The dose of N was 75 kg ha^{-1}. The fertiliser was applied around the mounds and forked in.

Groundnut was given a uniform fertiliser dose of 10:20:20 kg of NPK per hectare one month after planting. Fertiliser was applied in between the rows of groundnut and forked in.

3.5.5. Planting

Planting of cassava and groundnut were done on the same day on 24.7.1983. Cassava stakes of 20 cm length were planted on the top of mounds. The groundnut was sown at the rate of 45 kg per hectare using one seed per hole. The seed was pressed into the soil by hand to a depth of 1.[illegible] cm and covered with soil. Two rows of groundnut were planted between the rows of cassava at a spacing of 25 cm x 15 cm.

3.5.6. After cultivation

In general, germination of stakes were good. Ungerminated stakes were replaced by fresh stakes ten days after planting. Excess sprouts were removed retaining two healthy sprouts, two week after emergence. Germination of groundnut was satisfactory and wherever necessary, gap filling was done one week after sowing. Two weedings were given one at 30 DAP and second at the time of earthing up after the harvest of the groundnut and the incorporation of bhusa. At the flowering time of groundnut lime (1000 kg ha^{-1}) was applied and the soil was slightly stirred in order to facilitate pegging of groundnut.

3.5.7. Harvest

Groundnut was harvested at 110 DAP, on 10.11.1983. The main crop of cassava was harvested eight months after planting on 3.4.1984.

3.6. Pre-harvest observations

3.6.1. Cassava

Three plants per plot were earmarked for taking observations.

3.6.1.(i) Number of leaves per plant

The total number of leaves present at each observation were recorded by counting the number of fully opened leaves as well as the leaf scars from the base to the top of the stem on both the shoots. The observations were recorded at monthly intervals upto six months after planting.

3.6.1.(ii) Height of plant

Height of the tallest of the two shoots of each plant was measured from the base of the sprouts to the tip of the unopened bud at 30, 60, 90 and 120 DAP and at harvest.

3.6.1.(iii) Girth of stem

This was recorded by measuring the girth at 5 cm above the base of shoot of each plant at 30, 60, 90 and 120 DAP and at harvest.

3.6.1.(iv) Canopy spread

This was recorded by measuring the diameter of the leaf spread horizontally in NE and SW direction, and the averages of the two was taken as canopy spread. This was recorded at 30, 60, 90 and 120 DAP. Since there is overlapping of leaves after 120 days this observation could not be taken after 120 DAP.

3.6.1.(v) Leaf area index (LAI)

Leaf area was measured by punch method. Hundred uniform leaf punches of known area were taken. The dry weight of the leaf punches and the total foliage were found out separately. Leaf area was then calculated by using area; weight relationship and from this LAI was worked out by using the formula given by Watson (1947).

3.6.1.(vi) Net assimilation rate (NAR)

The procedure suggested by Buttery (1970) was followed for calculating NAR.

3.6.2. Groundnut

3.6.2.(i) Height of plant

Height of the plant was measured from the base of the sprout to the tip of the unopened leaves at 45 and 90 DAP.

3.6.2.(ii) Leaf area index

Leaf area index was determined at 45 and 90 DAS by using the same method as in the case of cassava.

3.7. Post harvest observations

3.7.1. Cassava

3.7.1.(i) Number of tubers

The number of tubers per plant was counted.

3.7.1.(ii) Length of tuber

The average length of tubers was worked out by measuring the length of tubers from the observation plants.

3.7.1.(iii) Girth of tuber

Girth measurements were recorded from the same tubers that were used for length measurements. Girth values were recorded at three places, namely at the centre and both ends of the tuber. The average was taken as the girth.

3.7.1.(iv) Tuber yield

After the harvest of the crop the tubers were separated and the soil adhering to the tubers were removed and the fresh weight of the tuber from the net plot was recorded.

3.7.1.(v) Shoot weight

The total weight of the stem was taken at the time of harvest.

3.7.1.(vi) Utilisation index (UI)

UI is the ratio of total root weight to shoot weight or fresh weight basis. This was found out from the observations recorded in tuber weight and shoot weight of the observational plants.

3.7.2. Groundnut

3.7.2.(i) Pod yield

Pod yield from each net plot of cassava was recorded after sun drying the pods.

3.7.2.(ii) Bhusa yield

After removing the pods from groundnut plant, the weight of bhusa in each plot was recorded.

3.8. Quality characters of the tuber

The rind was removed and the flesh alone was taken for the analysis.

3.8.1. Dry matter content

Uniform quantity (100 g) of flesh from the tuber from each treatment were taken and chopped into small pieces and dried to consistant weight in a hot air oven at 105°C. The dry matter obtained is expressed in percentage (A.O.A.C. 1969).

3.8.2. Starch content

Starch content of the tuber was estimated by using potassium ferricyanide method (Pigman, 1970). The values are expressed on dry weight basis as percentage.

3.8.3. Crude protein content

The nitrogen content of oven dried sample from each plot was estimated by using modified micro-kjeldahl method (Jackson, 1973). Nitrogen values were multiplied by the factor 6.25 (A.O.A.C. 1969) for obtaining the crude protein content.

3.8.4. Hydrocyanic acid content

The HCN content of fresh tuber samples were estimated by calorimetric method suggested by Indira and Sinha (1969).

3.9. Plant analysis and uptake studies

3.9.1. Plant analysis

Plant samples from tuber, stem, petiole and leaf were dried at 80 $\pm$ 5°C, ground and used for chemical analysis. The contents of N,P and K were analysed, using the methods given below.

3.9.1(i) Nitrogen

The total nitrogen content of sample was determined by the modified micro-Kjeldahl method (Jackson, 1973).

3.9.1.(ii) Phosphorus and Potassium

Phosphorus content was determined by Vanado-Molybdo phosphoric yellow colour method and potassium content by using 'EEL' Flame photometer (Jackson, 1973) in perchloricnitric acid extract (Hesse, 1971).

3.9.2. Uptake studies

The total uptake of N,P and K by cassava was calculated from the contents of these nutrients in the tuber, stem, petiole and leaf and their corresponding dry weight.

3.9.3. N,P and K content of bhusa in groundnut

This was found out by using the same method adopted for cassava.

3.10. Soil analysis

The total nitrogen, available phosphorus and potassium content of the soil sample from each plot were analysed at 30, 60, 90 and 120 DAP and at harvest using the method already mentioned (3.1.1.).

3.11. Land Equivalent Ratio (LER)

LER was worked out from the relative yields of both the crops (Willey and Mead, 1980) as given below:

$$LER = L_A + L_B = \frac{Ya}{Sa} + \frac{Yb}{Sb} \quad \text{where}$$

L_A and L_B - LER for individual crops

Ya and Yb - individual crop yield in intercropping

Sa and Sb - individual sole crop yield

For this purpose sole crop of groundnut was also raised at a spacing of 25 cm x 15 cm in 3 plots of 5.25 m x 4.5 m. All the cultural practices for sole crop of groundnut, as per KAU (1982) were followed.

3.12. Statistical analysis

The data were analysed statistically following the methods of Snedecor and Cochran (1967).

Results

RESULTS

Results of the study on "fertiliser management in cassava-groundnut intercropping system", the effect of the treatments on growth characters, yield and quality of cassava tuber, on the uptake of N, P and K by cassava and the intercrop and their effect on soil fertility are reported in this chapter. The various observations are statistically analysed and the mean values are presented in Table 1 to 39 and the corresponding analysis of varience in Appendices I to XVIII.

4.1. Growth characters

4.1.1. Cassava

4.1.1. (i) Number od leaves

The data on number of leaves at different stages of growth of cassava (Table 1) showed that there was no significant difference in number of leaves produced by the plant grown either in sole crop or intercropped with groundnut.

The results also showed that levels of N and time of application of N and K did not significantly influence the number of leaves produced by the plant till 90 DAP. Thereafter upto harvest levels of N had shown significant effect on number of leaves. N_2 had given more number of leaves than N_1 at all stages after 90 DAP.

Table 1. Number of leaves of cassava at different stages of growth

Treatments	Growth stages (DAP)*					
	30	60	90	120	150	180
<u>Cropping systems</u>						
S_0 Sole cassava	16.22	46.59	79.15	127.3	150.4	163.4
S_1 Cassava + groundnut	17.17	49.70	84.07	122.9	150.8	164.3
CD (0.05)	NS	NS	NS	NS	NS	NS
SEm ±	1.48	1.71	2.82	3.31	0.99	1.37
<u>Levels of nitrogen</u>						
N_1 56.25 kg ha^{-1}	17.57	48.28	81.17	119.7	147.1	159.6
N_2 75 kg ha^{-1}	18.43	48.50	82.06	130.[illegible]	154.1	168.2
CD (0.05)	NS	NS	NS	9.57	2.86	3.96
SEm ±	1.48	1.71	2.82	3.31	0.99	1.37
<u>Time of application (DAP)</u>						
T_1 (15, 60 and 90)	18.84	52.24	88.40	13 .6	156.4	168.6
T_2 (30, 60 and 90)	13.80	45.93	77.02	130.0	151.5	164.4
T_3 (15, 75 and 120)	16.75	51.45	85.65	128.0	156.8	170.4
T_4 (basal, 60 and 90)	17. 1	43.94	75.39	108.7	137.7	152.0
CD (0.05)	NS	NS	NS	13.54	4.05	5.60
SEm ±	2.09	2.42	4.0	4.68	1.4	1.94

* DAP - Days after planting

Regarding time of application, at 120 DAP T_1, T_2 and T_3 were on par and was significantly superior to control (T_4). At 150 DAP treatments receiving 1st dose of N and K at 15 DAP (T_1 and T_3) produced higher number of leaves than the treatments where 1st dose was given at planting (T_4) or at 30 DAP (T_2). At 180 DAP T_1, T_2 and T_3 were on par and had recorded more number of leaves than T_4. T_2 was significantly higher than T_4 and was on par with T_1.

Number of leaves produced by the plant was not significantly affected by any of the treatment interactions.

4.1.1.(ii) Height of the plant

The data presented in Table 2 showed that the height of cassava plants was not significantly different in sole and intercropped cassava in all stages except at harvest where the intercropped cassava recorded more height.

Higher level of N resulted in taller plants at all stages even though the difference was not significant at 30 and 90 DAP.

In general the treatment T_1 recorded higher plant height than all other treatments though the difference was statistically significant at all stages except at 30 DAP. It produced significantly taller plants than T_4 at all stages from 60 DAP. T_1 and T_3 were on par at all stages

Table 2. Height of cassava at different stages of growth (cm)

Treatment	Growth stages (DAP)*				
	30	60	90	120	Harvest
Cropping systems					
C_0 Sole cassava	20.6	65.0	115.5	183.4	232.8
C_1 Cassava + groundnut	22.5	65.33	116.7	180.7	242.4
CD (0.05)	NS	NS	NS	NS	9.71
SEm ±	0.95	1.24	2.70	2.74	3.02
Levels of nitrogen					
N_1 56.25 kg ha^{-1}	20.6	61.8	116.1	181.4	227.0
N_2 75 kg ha^{-1}	22.6	68.5	122.0	181.7	248.2
CD (0.05)	NS	3.50	NS	NS	8.71
SEm ±	0.95	1.24	2.70	2.74	3.02
Time of application (DAP)					
T_1 (15, 60 and 90)	23.0	75.3	127.4	189.2	259.4
T_2 (30, 60 and 90)	19.9	65.0	114.1	186.4	216.0
T_3 (15, 75 and 120)	24.0	66.8	127.6	175.1	258.2
T_4 (basal, 60 and 90)	21.3	52.7	108.7	175.1	216.7
CD (0.05)	NS	5.03	11.41	11.2	12.31
SEm ±	1.33	1.75	3.95	3.89	4.27

* Days after planting

except at 60 DAP. T_2, where the 1st dose of fertiliser was applied at 30 DAP, was significantly inferior to T_1 and T_3 at harvest.

The effect of interaction between treatment was not significant.

4.1.1.(iii) Girth of stem

The mean values presented in Table 3, showed that intercropping of groundnut did not have any significant influence on the girth of cassava plants. The higher level of N (N_2) resulted in more girth for the plants eventhough the difference was statistically significant only at 90 DAP.

Time of application had a significant effect on girth at 90 DAP and at harvest. T_1 and T_3 produced significantly more girth than T_2 and control (T_4) which were on par.

4.1.1.(iv) Canopy spread

The results (Table 4) showed that neither cropping system nor levels of N had any significant effect on the spread of the canopy at any stage. The treatment combinations also did not have any significant effect.

The effect of time of application of N and K was significant at 30 and 60 DAP. At 30 DAP T_1 and T_3 had produced more canopy spread whereas at 60 DAP this

Table 3. Girth of cassava stem (cm) at different stages of growth

Treatments	Growth stages (DAP) *				
	30	60	90	120	Harvest
Cropping systems					
S_0 Sole cassava	2.[illegible]6	3.[illegible]2	5.13	6.1	6.71
S_1 Cassava + groundnut	2.07	3.82	5.0	6.0	6.79
CD (0.05)	NS	NS	NS	NS	NS
SEm ±	0.106	0.226	0.067	0.057	0.059
Levels of nitrogen					
N_1 56.25 kg ha^{-1}	2.13	3.86	4.9	6.0	6.70
N_2 75 kg ha^{-1}	2.20	3.91	5.23	6.1	6.86
CD (0.05)	NS	NS	0.195	NS	NS
SEm ±	0.106	0.226	0.067	0.057	0.059
Time of application (DAP)					
T_1 (15, 50 and 90)	2.[illegible]	[illegible]	5.32	6.14	7.11
T_2 (30, 60 and 90)	2.16	3.82	4.9	6.2	6.57
T_3 (15, 75 and 120)	2.09	3.91	5.25	6.1	6.88
T_4 (basal, 60 and 90)	2.07	3.[illegible]	4.8	6.[illegible]	6.56
CD (0.05)	NS	NS	0.275	NS	0.243
SEm ±	0.153	0.32	0.095	0.081	0.084

* Days after planting

Table 4. Canopy spread of cassava at different stages of growth (cm)

Treatment	Growth stages (DAP)*			
	30	60	90	120
<u>Cropping systems</u>				
S_0 Sole cassava	30.01	63.17	76.8	79.56
S_1 Cassava + groundnut	40.24	62.67	79.4	81.25
CD (0.05)	NS	NS	NS	NS
SEm ±	1.47	2.05	0.98	0.505
<u>Levels of nitrogen</u>				
N_1 56.25 kg ha^{-1}	39.49	59.75	78.5	79.93
N_2 75 kg ha^{-1}	38.76	66.09	77.7	80.89
CD (0.05)	NS	NS	NS	NS
SEm ±	1.47	2.85	0.98	0.505
<u>Time of application (DAP)</u>				
T_1 (15, 60 and 90)	42.6	63.35	78.4	82.12
T_2 (30, 60 and 90)	32.4	71.8	77.5	72.42
T_3 (15, 75 and 120)	41.9	63.65	77.96	80.31
T_4 (basal, 60 and 90)	39.70	52.86	68.6	70.10
CD (0.05)	6.01	11.67	NS	NS
SEm ±	2.08	4.04	1.39	0.715

* Days after planting

was recorded by T_2. At the same time at 90 and 120 DAP there was no significant effect noticed.

4.1.1.(v) Leaf area index

It was observed from the Table 5 that there was no significant difference between the LAI of intercropped and sole cassava at all stages except at 90 DAP. Higher dose of N resulted in higher LAI at all stages and was statistically significant at 60 DAP.

The treatments where the 1st dose of N and K was applied at 15 (T_1 and T_3) or 30 (T_2) DAP resulted in higher LAI than the control (T_4) where the 1st dose was applied as basal. However there was no significant difference between the treatments at 120 DAP. The effect of interaction on LAI was not statistically significant.

4.1.1.(vi) Net assimilation rate

The difference between NAR of sole and intercropped cassava was not significant (Table 6) in both periods of observation.

Regarding levels of N, 75 kg ha^{-1} resulted in significantly higher NAR between 90 to 120 DAP. However the NAR was not significant between 60 to 90 DAP.

As far as time of application is concerned T_1 recorded the maximum NAR of 4.89 $g/m^2/day$ at 60 to 90 days stage which was significantly superior to all

Table 5. Leaf area index of cassava at different stages of growth

Treatment	Growth stages (DAP)*		
	60	90	120
Cropping systems			
S_0 Sole cassava	0.70	1.01	2.32
S_1 Cassava + groundnut	0.68	1.19	2.47
CD (0.05	NS	0.07	NS
SEm ±	0.03	0.025	0.09
Levels of nitrogen			
N_1 56.25 kg ha^{-1}	0.63	1.07	2.29
N_2 75 kg ha^{-1}	0.75	1.12	2.50
CD (0.05)	0.09	NS	NS
SEm ±	0.03	0.025	0.09
Time of application(DAP)			
T_1 (15, 60 and 90)	0.73	1.23	2.20
T_2 (30, 60 and 90)	0.75	1.17	2.41
T_3 (15, 75 and 120)	0.73	1.16	2.29
T_4 (basal, 60 and 90)	0.53	0.83	2.45
CD (0.05)	0.13	0.10	NS
SEm ±	0.05	0.036	0.14

* Days after planting

Table 6. Net assimilation rate of cassava at different stages of growth ($g/m^2/day$)

Treatment	Growth stages (DAP)*	
	60 - 90	90 - 120
Cropping systems		
S_0 Sole cassava	3.65	10.74
S_1 Cassava + groundnut	4.09	11.09
CD (0.05)	NS	NS
SEm ±	0.19	0.57
Levels of nitrogen		
N_1 56.25 kg ha^{-1}	3.98	9.89
N_2 75 kg ha^{-1}	3.75	11.93
CD (0.05)	NS	1.63
SEm ±	0.19	0.57
Time of application (DAP)		
T_1 (15, 60 and 90)	4.89	10.57
T_2 (30, 60 and 90)	3.81	9.87
T_3 (15, 75 and 120)	4.07	11.80
T_4 (basal, 60 and 90)	2.58	11.43
CD (0.05)	0.81	NS
SEm ±	0.27	0.80

* Days after planting

other treatments. This was followed by T_3 and T_2 which were also significantly superior to T_4. However, the difference between the treatments were not significant at 90 to 120 days period.

4.1.2. Groundnut

4.1.2.(i) Height of plant

The results given in Table 7 showed that the height of groundnut was not influenced by levels of N. However, time of application of N and K to cassava had significant influence on height at 45 and 90 DAP. Control (T_4) recorded maximum height than T_1, T_2 and T_3 which were on par.

4.1.2.(ii) Leaf area index

Table 7 showed that the LAI of groundnut at 45 and 90 DAP was not influenced by levels of N and time of application of N and K to cassava. However, T_2 and T_4 showed higher LAI than T_1 and T_3 at these stages.

4.2. Yield attributes and yield

4.2.1. Cassava

4.2.1.(i) Number of tubers per plant

The mean values on number of tubers per plant are given in Table 8.

The results showed that cropping systems and time of application of N and K produced significant influence on tuber number. However, levels of N and the interactions between the treatments were not significant.

Table 7. Height and LAI of groundnut at 45 and 90 DAS

Treatment	Height (cm)		LAI	
	45 DAS*	90 DAS	45 DAS	90 DAS
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	30.40	71.66	0.90	2.25
N_2 75 kg ha^{-1}	30.84	70.13	1.13	2.13
CD (0.05)	NS	NS	NS	NS
SEm ±	0.42	0.61	0.03	0.036
Time of application (DAP)				
T_1 (15, 60 and 90)	30.6	70.76	0.925	1.94
T_2 (30, 60 and 90)	29.86	68.74	1.21	2.42
T_3 (15, 75 and 120)	29.94	69.49	0.895	2.13
T_4 (basal, 60 and 90)	32.7	75.57	1.045	2.27
CD (0.05)	1.83	5.75	NS	NS
SEm ±	0.61	0.86	0.06	0.072

* DAS - Days after sowing

Table 8. Number of tubers/plant

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	9.78	8.51	9.27	7.60	8.58	9.23	8.79
S_1	10.84	9.27	9.33	8.71	9.39	9.73	9.56
Mean	10.31	8.89	9.30	8.16	8.98	9.48	
N_1	9.69	8.71	8.94	7.83			
N_2	10.81	9.07	9.66	8.49			

CD (0.05) S- 0.70 SEm $\pm$ S, N - 0.24

T- 0.90 T, SN - 0.35

ST, NT - 0.48

S_0 - Sole cassava
S_1 - Cassava + groundnut
N_1 - 56.25 kg N ha^{-1}
N_2 - 75 kg N ha^{-1}
T_1 - 15, 60 and 90 DAP
T_2 - 30, 60 and 90 DAP
T_3 - 15, 75 and 120 DAP
T_4 - basal, 60 and 90 DAP

Intercropped plots produced on an average 9.6 tubers per plant. This was significantly higher than that produced in sole cassava. The higher levels of N resulted in more number of tubers per plant eventhough the difference was not statistically significant.

The treatment T_1 produced significantly higher number of tubers than all other treatments. This was followed by T_3 which was significantly superior to T_4 and was on par with T_2.

4.2.1.(ii) Length of tuber

As in the case of number of tubers the effect of intercropping and time of application of N and K was significant whereas the levels of N and interactions between treatments were not significant (Table 9).

Intercropped cassava produced significantly longer tubers than sole cassava.

Regarding the time of application, T_1 had produced maximum tuber length followed by T_4 and T_3. T_2 was significantly inferior to T_1.

4.2.1.(iii) Girth of tuber

From the results (Table 10) it was observed that intercropping, levels of N and time of application had a significant influence on girth of tuber. However the interactions were not significant.

Table 9. Length of tuber (cm)

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	24.9	20.56	25.56	24.33	21.56	23.46	23.34
S_1	28.7	25.91	25.91	25.52	25.59	26.01	25.80
	26.84	23.24	25.73	24.93	23.57	24.74	
N_1	26.30	21.75	25.86	24.4			
N_2	27.38	24.73	25.98	24.86			

S_0 - Sole cassava

S_1 - Cassava + groundnut

N_1 - 56.25 kg N ha^{-1}

N_2 - 75 kg N ha^{-1}

T_1 - 15, 60 and 90 DAP

T_2 - 30, 60 and 90 DAP

T_3 - 15, 75 and 120 DAP

T_4 - basal, 60 and 90 DAP

CD (0.05) S - 2.09 SEm ± S, N - 0.73

T - 2.96 T, SN - 1.03

ST, NT - 1.45

Table 10. Girth of tuber (cm)

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	13.88	12.11	15.91	12.15	12.56	14.46	13.50
S_1	14.81	13.63	15.03	13.05	14.17	14.59	14.38
Mean	14.35	12.87	15.47	12.60	13.37	14.52	
N_1	13.51	13.90	14.20	12.86			
N_2	15.18	12.85	16.75	13.30			

CD (0.05) S, N - 0.79 SEm ± S, N - 0.27

T - 1.12 T, SN - 0.39

ST, NT - 0.55

S_0 - Sole cassava

S_1 - Cassava + groundnut

N_1 - 56.25 kg N ha^{-1}

N_2 - 75 kg N ha^{-1}

T_1 - 15, 60 and 90 DAP

T_2 - 30, 60 and 90 DAP

T_3 - 15, 75 and 120 DAP

T_4 - basal, 60 and 90 DAP

Intercropped cassava produced tubers of higher girth and was significantly superior to sole cassava. As far as levels of N is concerned 75 kg N ha^{-1} had given significantly more tuber girth.

The treatments where 1st dose of N and K application was delayed for 15 days (T_1 and T_3) had given a significant increase in tuber girth over the treatments were 1st dose was given as basal (T_4), or at 30 DAP (T_2) eventhough the former two were on par. The treatments T_2 and T_4 were also on par.

4.2.1.(iv) Tuber yield

Tuber yield data presented in Table 11 showed that intercropping, levels of N, time of application of N and K and their interactions had significant influence on tuber yield.

Intercropped cassava had given a significantly higher yield of tuber than sole cropped cassava.

Increasing the N dose from (N_1) 56.25 kg per hectare to (N_2) 75 kg per hectare had also resulted in a significant increase in tuber yield from 19.18 to 20.97 tonnes per hectare.

There was a very good response for the time of application of N and K. Application of 1st dose of fertiliser at 15 DAP (T_1 and T_3) had given a significantly higher tuber yield than applying the fertiliser either at 30 DAP (T_2) or at planting (T_4). The treatment T_1

Table 11. Tuber yield (t ha^{-1})

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	20.47	17.86	20.58	18.40	18.38	20.44	19.60
S_1	22.84	18.69	23.52	17.40	19.99	21.50	20.64
Mean	21.65	18.27	22,05	17.90	19.18	20.97	
N_1	20.88	18.49	20.95	18.27			
N_2	22.23	18.05	22.88	17.53			

S_0 - Sole cassava

S_1 - Cassava + groundnut

N_1 - 56.25 kg N ha^{-1}

N_2 - 75 kg N ha^{-1}

T_1 - 15, 60 and 90 DAP

T_2 - 30, 60 and 90 DAP

T_3 - 15, 75 and 120 DAP

T_4 - basal 60 and 90 DAP

CD (0.05) S, N - 0.48; T, SN - 0.69; ST, NT - 0.97

SEm $\pm$ S, N - 0.17; T, SN - 0.24; ST, NT - 0.34

and T_3 were on par and T_2 and T_4 were also on par eventhough T_4 had recorded the lowest yield.

The interaction effect between the different combinations were significant. Among the S x T interactions it could be seen that S_1T_3 recorded the maximum yield which was on par with S_1T_1. These two combinations were significantly superior to all other S x T treatment combinations.

As far as S x N interactions are concerned the combination S_1N_2 recorded the maximum yield which was significantly superior to all other combinations. S_0N_2 was on par with S_1N_1 and both these treatments were significantly superior to S_0N_1.

Regarding the interaction between N level and time of application, the treatment N_2T_3 recorded maximum yield which was on par with N_2T_1. This was followed by the treatment combination N_1T_3 and N_1T_1 which were on par and was superior to the combination of T_2 and T_4 with N_1 and N_2.

4.2.1.(v) Utilisation index (UI)

The mean values of UI are presented in Table 12.

UI was significantly influenced by intercropping and time of application. Levels of N did not have any significant effect on UI.

Intercropped cassava had given a significantly higher UI than sole crop. The N and K application at

Table 12. Utilisation index

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	1.49	1.17	1.34	1.20	1.16	1.45	1.31
S_1	1.49	1.36	1.66	1.25	1.46	1.42	1.44
Mean	1.49	1.26	1.50	1.23	1.31	1.43	
N_1	1.28	1.25	1.49	1.21			
N_2	1.70	1.28	1.51	1.25			

S_0 - Sole cassava

S_1 - Cassava+groundnut

N_1 - 56.25 kg N ha^{-1}

N_2 - 75 kg N ha^{-1}

T_1 - 15, 60 and 90 DAP

T_2 - 30, 60 and 90 DAP

T_3 - 15, 75 and 120 DAP

T_4 - basal, 60 and 90 DAP

CD (0.05) S - 0.14; T, SN - 0.15

SEm $\pm$ S, N - 0.04; T, SN - 0.07; ST, NT - 0.09

15 DAP (T_1 and T_3) had given higher values of UI than T_2 and T_4 eventhough the latter two were on par.

As to the interactions, only the interaction between S x N was significant. The combination S_0N_1 produced a lower UI and was inferior to all other combinations.

4.2.2. Groundnut

4.2.2.(i) Pod yield

Table 13 revealed that individual effect of levels of N and time of application of N and K to cassava were significant. The treatment in which cassava was fertilised at the rate of 56.25 kg N ha^{-1} produced significantly higher yield than 75 kg N ha^{-1}. The treatment T_4 produced significantly higher yield than T_1 and T_3 and was on par with T_2.

4.2.2.(ii) Bhusa yield

It was observed (Table 14) that bhusa yield of groundnut was not significantly influenced by levels of N and time of application of N and K to cassava. However a trend was seen wherein application of N at higher levels resulted in more bhusa yield.

4.3. Quality attributes of tubers

4.3.1. Dry matter content

From the results (Table 15) it could be seen that intercropping, levels of N, time of application of N and K and their interactions did not significantly influence the dry matter percentage of tuber. However, tubers from intercropped cassava had more dry matter content than from the sole cassava plot.

Table 13. Pod yield of groundnut (kg ha^{-1})

Treatment	T_1	T_2	T_3	T_4	Mean
N_1	935.3	1030.8	772.8	1178.8	979.43
N_2	750.0	1039.7	787.4	927.6	876.18
Mean	842.63	1035.25	780.1	1053.2	

CD (0.05	N - 29.85	SEM $\pm$	N - 9.77
	T - 59.31		T - 19.54
			N x T - 39.09

Table 14. Bhusa yield (t ha^{-1})

Treatment	T_1	T_2	T_3	T_4	Mean
N_1	5.33	4.83	5.06	4.85	5.02
N_2	5.19	4.78	5.29	5.14	5.10
Mean	5.26	4.81	5.18	4.99	

SEm $\pm$ N - 0.15
T - 0.207
NT - 0.294

N_1 - 56.25 kg N ha^{-1} to cassava
N_2 - 75 kg N ha^{-1} to cassava
T_1 - 15, 60 and 90 DAP
T_2 - 30, 60 and 90 DAP
T_3 - 15, 75 and 120 DAP
T_4 - basal, 60 and 90 DAP

Table 15. Dry matter content of tuber (%)

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	36.7	37.7	38.4	31.9	36.8	35.6	36.2
S_1	39.7	38.0	37.7	39.5	37.9	39.5	38.7
Mean	38.2	37.8	38.1	35.7	37.4	37.5	
N_1	36.3	37.2	37.9	38.1			
N_2	40.2	38.5	38.2	33.3			

S_0 - Sole cassava
S_1 - Cassava + groundnut
N_1 - 56.25 kg N ha^{-1}
N_2 - 75 kg N ha^{-1}
T_1 - 15, 60 and 90 DAP
T_2 - 30, 60 and 90 DAP
T_3 - 15, 75 and 120 DAP
T_4 - basal, 60 and 90 DAP

SEm $\pm$ S,N - 1.13
T,SN - 1.60
ST,NT - 2.6

4.3.2. Starch content

Tubers from intercropped plot recorded a significantly higher starch content than those from sole cassava plot. (Table 16). Higher levels of N (75 kg ha^{-1}) produced significantly more starch content.

Application of N and K at T_1 and T_3 recorded almost same starch content and was significantly superior to T_2 and T_4. The interaction effect between the treatments were not significant except S x N.

4.3.3. Crude protein content

The crude protein content (Table 17) of cassava tuber was significantly influenced by levels of N and time of application. Intercropping and the combination of various treatments were not significant eventhough intercropped cassava recorded more protein content.

Crude protein content was higher in treatments receiving N at 75 kg ha^{-1}. Tubers from plots in which the 1st dose of N and K fertiliser was applied at 15 DAP (T_1 and T_3) had significantly higher protein content than those from plots where 1st dose was applied at planting (T_4) or at 30 DAP (T_2).

4.3.4. Hydrocyanic acid content

HCN content of tuber was not significantly influenced by any of the treatments (Table 18). However, higher level of N (75 kg ha^{-1}) tended to increase the

Tabld 16. Starch content of tuber (%)

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	67.13	64.19	68.3	63.0	63.1	68.6	65.8
S_1	71.78	66.7	70.7	67.6	69.3	68.8	68.9
Mean	69.46	65.45	69.5	65.3	65.2	68.7	
N_1	67.9	64.2	68.8	64.4			
N_2	70.9	67.3	70.1	66.2			

S_0 - Sole cassava
S_1 - Cassava + groundnut
N_1 - 56.25 kg N ha^{-1}
N_2 - 75 kg N ha^{-1}
T_1 - 15, 60 and 90 DAP
T_2 - 30, 60 and 90 DAP
T_3 - 15, 75 and 120 DAP
T_4 - basal, 60 and 90 DAP

CD (0.05) S,N - 1.35
T,SN - 1.91

SEm $\pm$ S, N - 0.47
T, SN - 0.66
ST, NT - 0.94

Table 17. Crude protein content of tuber (%)

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	2.15	1.57	2.04	1.71	1.64	2.09	1.87
S_1	2.66	1.78	2.23	1.56	2.0	2.11	2.06
Mean	2.40	1.68	2.13	1.64	1.82	2.10	
N_1	2.19	1.54	1.93	1.64			
N_2	2.62	1.82	2.33	1.64			

CD (0.05) N - 0.23 SEm $\pm$ S, N - 0.08
T - 0.32 T, SN - 0.11
ST, NT - 0.16

S_0 - Sole cassava
S_1 - Cassava + groundnut
N_1 - 56.25 kg N ha^{-1}
N_2 - 75 kg N ha^{-1}
T_1 - 15, 60 and 90 DAP
T_2 - 30, 60 and 90 DAP
T_3 - 15, 75 and 120 DAP
T_4 - basal, 60 and 90 DAP

HCN content. As in the case of crude protein T_1 and T_3 had more HCN content than T_2 and T_4.

The S x N and N x T interactions were significant. Nitrogen at 75 kg ha^{-1} to intercropped cassava has given significantly higher HCN content than N at 75 kg ha^{-1} under sole crop and 56.25 kg N ha^{-1} under both the systems.

Among the N x T interactions N_1T_2 recorded the lowest HCN content where-as N_2T_3 recorded the maximum values and the difference between these two treatments were significant. Similarly N_1T_1 also recorded significantly higher HCN content than N_1T_2 treatment.

4.4. Plant analysis

4.4.1. Cassava

4.4.1.1. Nitrogen content

(a) Leaf

The effect of different treatments on N content of leaves at different stages are presented in Table 19. Significant difference in leaf N content of cassava due to N levels was observed at the time of harvest wherein N at 75 kg ha^{-1} had given a higher content than at 56.25 kg ha^{-1}. This trend was seen in all the stages eventhough the difference was not statistically significant.

The effect of time of application of N and K on N content of leaf was significant at 60 and 90 DAP and at

Table 18. Hydrocyanic acid content of tuber (mg kg^{-1})

Treatment	T_1	T_2	T_3	T_4	N_1	N_2	Mean
S_0	107.50	95.41	124.80	108.78	102.38	106.87	107.63
S_1	119.56	110.00	106.24	103.24	110.24	118.54	111.23
Mean	113.53	102.71	115.52	106.01	106.32	112.71	
N_1	120.4	95.75	108.5	104.5			
N_2	106.6	111.66	122.0	109.78			

S_0 - Sole cassava
S_1 - Cassava + groundnut
N_1 - 56.25 kg N ha^{-1}
N_2 - 75 kg N ha^{-1}
T_1 - 15, 60 and 90 DAP
T_2 - 30, 60 and 90 DAP
T_3 - 15, 75 and 120 DAP
T_4 - basal, 60 and 90 DAP

CD (0.05) SN - 15.7
N×T - 22.21

SEm ± S, N - 3.84
T, SN - 5.44
ST, NT - 7.69

Table 19. Nitrogen content of cassava leaf at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping system				
S_0 Sole cassava	3.29	3.8	3.30	3.0
S_1 Cassava + groundnut	3.31	3.8	3.45	3.08
CD (0.05)	NS	NS	NS	NS
SEm ±	0.094	0.072	0.114	0.093
Levels of nitrogen				
N_1 56.25 Kg ha^{-1}	3.21	3.8	3.22	2.71
N_2 75. Kg ha^{-1}	3.39	3.9	3.53	3.27
CD (0.05)	NS	NS	NS	0.27
SEm ±	0.094	0.072	0.0114	0.093
Time of application (DAP)				
T_1 (15, 60 and 90)	3.34	3.7	3.47	3.52
T_2 (30, 60 and 90)	3.70	3.9	3.45	2.51
T_3 (15, 75 and 120)	3.19	4.1	3.21	3.55
T_4 (basal, 60 and 90)	2.96	3.6	3.36	2.58
CD (0.05)	0.38	0.30	NS	0.38
SEm ±	0.13	0.103	0.061	0.132

* Days after planting

harvest stage. At 60 DAP T_2 where the 1st dose of N and K was applied at 30 DAP showed significantly higher N content than T_3 and T_4 and was on par with T_1. The treatment where the 1st dose of N was applied at planting (T_4) recorded the lowest value. At 90 DAP T_3 recorded the maximum N content in leaves which was significantly superior to T_4 and T_1 and was on par with T_2. At harvest stage T_3 where the top dressing of N was given at 120 DAP recorded higher N content than the other treatments where the last dose was given at 90 DAP, except for T_1 which was on par with T_3.

(b) Petiole

Nitrogen content of petiole (Table 20) was not significantly influenced by intercropping. Significant difference due to levels of N was obtained at 60 DAP and at harvest whereas time of application had significant effect only at harvest. The higher dose of N at 75 kg ha^{-1} recorded significantly higher N content in petiole than the 56.25 kg ha^{-1}. Among the time of application treatments, T_3 showed a significantly higher N content than T_2 and T_4 (control). This was followed by T_1 and is significantly lesser than T_3.

(c) Stem

The results (Table 21) showed that upto 90 DAP the stem N content was not influenced by any of the treatment or their combinations. At 120 DAP and at harvest stage

Table 20. Nitrogen content of cassava petiole at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping system				
S_0 sole cassava	0.85	0.75	0.65	0.77
S_1 Cassava + groundnut	0.87	0.72	0.58	0.75
CD (0.05)	NS	NS	NS	NS
SEm ±	0.046	0.037	0.027	0.033
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	0.77	0.75	0.61	0.68
N_2 75 kg ha^{-1}	0.99	0.72	0.62	0.83
CD (0.05)	0.13	NS	NS	0.098
SEm ±	0.046	0.037	0.027	0.033
Time of application DAP)				
T_1 (15, 60 and 90)	0.82	0.70	0.67	0.79
T_2 (30, 60 and 90)	0.86	0.69	0.53	0.70
T_3 (15, 75 and 90)	0.91	0.72	0.64	0.91
T_4 (basal, 60 and 90)	0.85	0.83	0.62	0.63
CD (0.05)	NS	NS	NS	0.135
SEm ±	0.065	0.052	0.039	0.056

* Days after planting

Table 21. Nitrogen content of cassava stem at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
<u>Cropping system</u>				
S_0 Sole cassava	0.62	0.45	0.49	0.39
S_1 Cassava + groundnut	0.60	0.49	0.44	0.37
CD (0.05)	NS	NS	0.039	NS
SEm ±	0.031	0.023	0.014	0.013
<u>Levels of nitrogen</u>				
N_1 56.25 kg ha^{-1}	0.66	0.47	0.46	0.28
N_2 75 kg ha^{-1}	0.60	0.47	0.45	0.23
CD (0.05)	NS	NS	NS	0.036
SEm ±	0.031	0.023	0.014	0.013
<u>Time of application(DAP)</u>				
T_1 (15, 60 and 90)	0.69	0.43	0.53	0.46
T_2 (30, 60 and 90)	0.66	0.43	0.36	0.26
T_3 (15, 75 and 120)	0.60	0.52	0.60	0.37
T_4 (basal, 60 and 90)	0.60	0.51	0.32	0.23
CD (0.05)	NS	NS	0.065	0.052
SEm ±	0.045	0.33	0.019	0.018

* Days after planting

time of application had a significant influence on stem N content. The treatment T_1 and T_3 recorded higher N content than T_2 and T_4 at both these stages. The treatment T_4 recorded the lowest N content.

(d) Tuber

The data presented in Table 22 showed that intercropping had a significant effect on tuber N content upto 120 DAP. Intercropping resulted in higher N content in tuber at harvest eventhough the difference was not significant. The effect of levels of N and time of application of N and K were not significant upto 120 DAP but at the time of harvest the difference due to these treatments were significant. Higher levels of N (75 kg ha^{-1}) had more N in tuber than lower level (56.25 kg ha^{-1}). T_1 and T_3 where the 1st dose of N and K was applied at 15 DAP showed significantly higher content than T_2 where N and K was applied at 30 DAP or T_4 as basal.

(e) N uptake

The data on the effect of different treatments on N uptake by cassava at different stages of growth are presented in Table 23. Intercropping with groundnut resulted in significantly higher N uptake by cassava at 90 DAP and at harvest stage. However this effect was not statistically significant at 60 and 120 days

Table 22. Nitrogen content of cassava tuber at different stages of growth (%)

Treatments	Growth stages (DAP)*		
	90	120	Harvest
Cropping systems			
S_0 Sole cassava	0.34	0.21	0.30
S_1 Cassava + groundnut	0.44	0.26	0.33
CD (0.05)	0.054	0.036	NS
SEm ±	0.018	0.013	0.013
Levels of nitrogen			
N_1 56.25 kg ha^{-1}	0.38	0.24	0.30
N_2 75 kg ha^{-1}	0.39	0.23	0.34
CD (0.05)	NS	NS	0.036
SEm ±	0.018	0.013	0.013
Time of application (DAP)			
T_1 (15, 60 and 90)	0.37	0.25	0.39
T_2 (30, 60 and 90)	0.40	0.25	0.28
T_3 (15, 75 and 120)	0.43	0.23	0.35
T_4 (basal, 60 and 90)	0.35	0.22	0.27
CD (0.05)	NS	NS	0.051
SEm ±	0.026	0.018	0.017

* Days after planting

Table 23. Total nitrogen uptake (mg/plant) by cassava at different stages of growth

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
<u>Cropping systems</u>				
S_0 Sole cassava	1003.1	1732.4	3888.9	2502.4
S_1 Cassava + groundnut	1073.5	1986.5	4020.1	2951.6
CD (0.05)	NS	182.75	NS	407.2
SEm ±	47.3	63.28	182.5	141.01
<u>Levels of nitrogen</u>				
N_1 56.25 kg ha^{-1}	964.2	1755.7	3546.5	2693.1
N_2 75 kg ha^{-1}	1112.4	1963.2	4362.5	2843.9
CD (0.05)	136.6	182.75	627.15	NS
SEm±	47.3	63.28	182.5	141.01
<u>Time of application (DAP)</u>				
T_1 (15, 60 and 90)	1132.0	1963.4	4303.3	4020.1
T_2 (30, 60 and 90)	1197.3	1932.4	3638.8	2957.4
T_3 (15, 75 and 120)	1182.9	2231.0	3864.3	3001.4
T_4 (basal, 60 and 90)	641.0	1358.1	4011.7	2429.1
CD (0.05)	193.2	258.5	NS	575.2
SEm ±	66.9	89.5	258.1	199.4

* Days after planting

stages. Higher level of N application resulted in higher N uptake by cassava, eventhough the difference was not statistically significant at harvest stage.

The time of application showed that control (T_4) resulted in significantly lower uptake than the other treatments at 60 and 90 DAP. At 60 DAP all other treatments were on par whereas at 90 days stage T_3 recorded maximum N uptake which was significantly higher than T_1 and T_2 which were on par. There was no significant difference between the treatments at 120 DAP. At harvest stage T_1 recorded the maximum N uptake which was significantly superior to T_3. The treatment T_2 and T_4 were on par and recorded significantly lower N uptake than the other treatments.

4.4.1.2. Phosphorus content

(a) Leaf

Results presented in Table 24 showed that P content of leaf was not influenced by intercropping. The content of P in leaf was not influenced by level of N and time of application of N and K at all stages except at 60 DAP.

(b) Petiole

Phosphorus content of petiole (Table 25) was influenced by intercropping at 90 and 120 DAP wherein the intercropped cassava showed higher P content in petiole than sole cassava. Levels of N did not show

Table 24. Phosphorus content of cassava leaf at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping systems				
S_0 Sole cassava	0.14	0.14	0.10	0.098
S_1 Cassava + groundnut	0.15	0.14	0.11	0.10
CD (0.05)	NS	NS	NS	NS
SEm ±	0.008	0.0036	0.004	0.005
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	0.16	0.14	0.10	0.11
N_2 75 kg ha^{-1}	0.13	0.13	0.11	0.10
CD (0.05)	0.025	NS	NS	NS
SEm ±	0.008	0.0036	0.004	0.005
Time of application (DAP)				
T_1 (15, 60 and 90)	0.12	0.15	0.10	0.105
T_2 (30,60 and 90)	0.13	0.13	0.10	0.11
T_3 (15, 75 and 120)	0.13	0.13	0.11	0.10
T_4 (basal, 60 and 90)	0.14	0.14	0.11	0.091
CD (0.05)	NS	NS	NS	NS
SEm ±	0.012	0.005	0.006	0.007

* Days after planting

Table 25. Phosphorus content of cassava petiole at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping systems				
S_0 Sole cassava	0.16	0.15	0.24	0.050
S_1 Cassava + groundnut	0.15	0.17	0.28	0.054
CD (0.05)	NS	0.013	0.027	NS
SEm ±	0.006	0.005	0.009	0.003
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	0.17	0.16	0.27	0.053
N_2 75 kg ha^{-1}	0.14	0.17	0.25	0.052
CD (0.05)	0.019	NS	NS	NS
SEm ±	0.006	0.005	0.009	0.003
Time of application (DAP)				
T_1 (15, 60 and 90)	0.14	0.15	0.25	0.054
T_2 (30, 60 and 90)	0.14	0.16	0.25	0.061
T_3 (15, 75 and 120)	0.17	0.15	0.26	0.048
T_4 (basal, 60 and 90)	0.16	0.17	0.27	0.046
CD (0.05)	NS	NS	NS	NS
SEm ±	0.009	0.007	0.013	0.004

* Days after planting

any significant influence on P content at all stages except at 60 DAP. Likewise the time of application of N and K did not influence the P content of cassava at any of the stages.

(c) Stem and tuber

From the Table 26 and 27, it could be seen that intercropping, levels of N or time of application treatments did not have any effect on the P content of either stem or tuber of cassava plant.

(d) P uptake

P uptake by cassava (Table 28) was not influenced by intercropping and levels of N. The effect of time of application of N and K on P uptake was significant at 90 DAP and at harvest stage. Control (T_4) plot had given significantly lower P uptake than other treatments at 90 DAP. At harvest T_2 and T_4 were on par.

4.4.1.3. Potassium content

(a) Leaf

Table 29 showed the effect of cropping systems, levels of N and time of application of N and K on K content in cassava leaves. Intercropping had significant influence on leaf K content at all stages except at 60 DAP. At 90 DAP and at harvest intercropped cassava recorded higher K content in the leaf.

Table 26. Phosphorus content of cassava stem at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
<u>Cropping systems</u>				
S_0 Sole cassava	0.14	0.17	0.046	0.043
S_1 Cassava + groundnut	0.12	0.18	0.055	0.047
CD (0.05)	NS	NS	NS	NS
SEm ±	0.006	0.005	0.005	0.003
<u>Levels of nitrogen</u>				
N_1 56.25 kg ha^{-1}	0.14	0.18	0.056	0.045
N_2 75 kg ha^{-1}	0.13	0.18	0.055	0.045
CD (0.05)	NS	NS	NS	NS
SEm ±	0.006	0.005	0.005	0.003
<u>Time of application (DAP)</u>				
T_1 (15, 60 and 90)	0.11	0.18	0.058	0.045
T_2 (30, 60 and 90)	0.14	0.18	0.036	0.048
T_3 (15, 75 and 120)	0.13	0.18	0.059	0.039
T_4 (basal, 60 and 90)	0.13	0.18	0.059	0.046
CD (0.05)	NS	NS	NS	NS
SEm ±	0.0096	0.007	0.007	0.0039

* Days after planting

Table 27. Phosphorus content of cassava tuber at different stages of growth (%)

Treatments	Growth stages (DAP)*		
	90	120	Harvest
Cropping systems			
S_0 Sole cassava	0.050	0.14	0.035
S_1 Cassava + groundnut	0.056	0.14	0.035
CD (0.05)	NS	NS	NS
SEm $\pm$	0.0032	0.0047	0.0017
Levels of nitrogen			
N_1 56.25 kg ha^{-1}	0.049	0.14	0.035
N_2 75 kg ha^{-1}	0.057	0.14	0.034
CD (0.05)	NS	NS	NS
SEm $\pm$	0.0032	0.0047	0.0017
Time of application (DAP)			
T_1 (15, 60 and 90)	0.049	0.13	0.035
T_2 (30, 60 and 90)	0.054	0.15	0.035
T_3 (15, 75 and 120)	0.054	0.14	0.034
T_4 (basal, 60 and 90)	0.047	0.14	0.035
CD (0.05)	NS	NS	NS
SEm $\pm$	0.0045	0.0067	0.0027

* Days after planting

Table 28. Total phosphorus uptake (mg/plant) by cassava different stages of growth

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
<u>Cropping systems</u>				
S_0 Sole cassava	83.9	145.9	474.5	270.6
S_1 Cassava + groundnut	84.6	160.8	553.0	304.5
CD (0.05)	NS	NS	NS	NS
SEm ±	3.7	7.17	29.49	15.35
<u>Levels of nitrogen</u>				
N_1 56.25 kg ha^{-1}	86.5	147.3	495.5	279.9
N_2 75 kg ha^{-1}	81.9	159.3	567.9	295.3
CD (0.05)	NS	NS	NS	NS
SEm ±	3.7	7.17	29.49	15.35
<u>Time of application (DAP)</u>				
T_1 (15, 60 and 90)	83.9	158.9	563.2	342.3
T_2 (30, 60 and 90)	91.8	164.8	467.3	261.4
T_3 (15, 75 and 120)	94.1	166.1	529.5	315.1
T_4 (basal, 60 and 90)	70.1	123.6	495.0	231.5
CD (0.05)	NS	29.3	NS	62.7
SEm ±	5.24	10.14	41.7	21.7

* Days after planting

Significant influence for levels of N was observed only at the time of harvest and the K content of the leaf was significantly higher in plots receiving 56.25 kg N ha^{-1}. The effect of time of applications were not significant at any of the growth stages of cassava.

(b) Petiole

From the Table 30 it could be observed that the K content of cassava petiole was not significantly influenced by intercropping with groundnut. Higher level of N (75 kg ha^{-1}) resulted in significantly superior K content in petiole at 90 DAP and at harvest whereas at 60 DAP the lower N level resulted in higher petiole K content and the treatment effects were not significant at 120 DAP.

With regard to the time of application, at 60 DAP it was observed that the petiole K content in T_4 was significantly superior to T_1, T_2 and T_3 which were on par. Effect of time of application treatment was not significant at later stages.

(c) Stem

Results presented in Table 31 indicate that the effect of intercropping on stem K content was significant only at 90 DAP and intercropped cassava recorded a higher value. Levels of N did not have any effect on this character. Application of N and K on stem K was also not significant upto 120 DAP. However the effect

Table 29. Potassium content of cassava leaf at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping systems				
S_0 Sole cassava	0.96	2.39	1.51	1.09
S_1 Cassava + groundnut	1.00	2.55	1.38	1.26
CD (0.05)	NS	0.105	0.085	0.106
SEm ±	0.047	0.036	0.035	0.037
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	0.96	2.5	1.45	1.17
N_2 75 kg ha^{-1}	1.00	2.45	1.44	1.02
CD (0.05)	NS	NS	NS	0.106
SEm ±	0.047	0.036	0.035	0.037
Time of application (DAP)				
T_1 (15, 60 and 90)	0.95	2.6	1.44	1.16
T_2 (30, 60 and 90)	1.05	2.5	1.41	1.076
T_3 (15, 75 and 120)	0.98	2.4	1.48	1.095
T_4 (basal, 60 and 90)	0.92	2.4	1.46	1.075
CD (0.05)	NS	NS	NS	NS
SEm ±	0.066	0.052	0.043	0.051

* Days after planting

Table 30. Potassium content of cassava petiole at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping systems				
S_0 Sole cassava	3.22	2.60	1,85	0.89
S_1 Cassava + groundnut	3.30	2.76	1.68	0.76
CD (0.05)	NS	NS	NS	NS
SEm ±	0.102	0.061	0.068	0.056
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	3.41	2.51	1.79	0.84
N_2 75 kg ha^{-1}	3.11	2.84	1.73	1.16
CD (0.05)	0.029	0.176	NS	0.164
SEm ±	0.102	0.061	0.068	0.056
Time of application (DAP)				
T_1 (15, 60 and 90)	3.11	2.76	1.73	1.03
T_2 (30, 60 and 90)	3.17	2.80	1.83	0.997
T_3 (15, 75 and 120)	3.10	2.55	1.80	1.10
T_4 (basal, 60 and 90)	3.64	2.58	1.72	0.845
CD (0.05)	0.42	NS	NS	NS
SEm ±	0.15	0.086	0.096	0.080

* Days after planting

Table 31. Potassium content of cassava stem at different stages of growth (%)

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping systems				
S_0 Sole cassava	1.2	1.64	0.98	0.64
S_1 Cassava + groundnut	1.0	1.82	0.98	0.65
CD (0.05)	NS	0.144	NS	NS
SEm ±	0.057	0.049	0.041	0.014
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	1.15	1.75	0.93	0.66
N_2 75 kg ha^{-1}	1.05	1.70	1.02	0.63
CD (0.05)	NS	NS	NS	NS
SEm ±	0.057	0.049	0.041	0.014
Time of application (DAP)				
T_1 (15, 60 and 90)	1.05	1.68	0.97	0.725
T_2 (30, 60 and 90)	1.15	1.60	0.96	0.585
T_3 (15, 75 and 120)	1.07	1.88	1.01	0.705
T_4 (basal, 60 and 90)	1.15	1.74	0.95	0.56
CD (0.05)	NS	NS	NS	0.060
SEm ±	0.081	0.071	0.057	0.020

* Days after planting

was significant at the time of harvest. T_1 recorded the maximum K content followed by T_3 and these two treatments were significantly higher than T_2 and T_4 which were on par.

(d) Tuber

Tuber K content (Table 32) in cassava was not affected by intercropping, levels of N and time of application of N and K at all stages of growth. However, time of application at 90DAP and intercropping at 120DAP showed a significant effect

(e) K uptake

The data on K uptake by cassava plant at different stages presented in Table 33 showed that the effect of intercropping and levels of N were significant at some stages of growth whereas the effect of time of application of N and K was significant at all the stages. Intercropped cassava gave significantly higher uptake of K at 90 days stage and at harvest.

Higher level of N (75 kg ha^{-1}) application had resulted in more K uptake by cassava than lower level (56.25 kg ha^{-1}) eventhough it was not significant at 60 DAP and at harvest stages.

Among the time of application treatments T_3 recorded the heighest uptake at 60 DAP and at harvest whereas T_1 recorded maximum value at 90 and 120 DAP. The two

Table 32. Potassium content of cassava tuber at different stages of growth (%)

Treatments	Growth stages (DAP)*		
	90	120	Harvest
Cropping systems			
S_0 Sole cassava	1.50	1.34	0.94
S_1 Cassava + groundnut	1.45	1.64	0.96
CD (0.05)	NS	0.194	NS
SEm ±	0.031	0.067	0.036
Levels of nitrogen			
N_1 56.25 kg ha^{-1}	1.52	1.43	0.95
N_2 75 kg ha^{-1}	1.44	1.56	0.95
CD (0.05)	NS	NS	NS
SEm ±	0.031	0.067	0.036
Time of application (DAP)			
T_1 (15, 60 and 90)	1.50	1.60	1.0
T_2 (30, 60 and 90)	1.20	0.55	0.87
T_3 (15, 75 and 120)	1.73	1.44	1.03
T_4 (basal, 60 and 90)	1.29	1.34	0.89
CD (0.05)	0.117	NS	NS
SEm ±	0.041	0.075	0.051

* Days after planting

Table 33. Total potassium uptake by cassava (mg/plant) at different stages of growth

Treatments	Growth stages (DAP)*			
	60	90	120	Harvest
Cropping systems				
S_0 Sole cassava	893.4	2376.8	5631.7	5682.3
S_1 Cassava + groundnut	953.0	2760.9	6139.4	6770.7
CD (0.05)	NS	229.2	NS	683.0
SEm ±	31.6	79.3	217.9	236.5
Levels of nitrogen				
N_1 56.25 kg ha^{-1}	902.7	2415.8	5288.9	5927.5
N_2 75 kg ha^{-1}	943.6	2721.9	6482.5	6525.5
CD (0.05)	NS	229.2	629.4	NS
SEm ±	31.6	79.3	217.9	236.5
Time of application (DAP)				
T_1 (15, 60 and 90)	936.0	2986.4	6723.9	7392.8
T_2 (30, 60 and 90)	946.9	2586.7	5656.3	5113.8
T_3 (15, 75 and 120)	1018.2	2906.4	6130.2	7648.5
T_4 (basal, 60 and 90)	801.5	1795.4	5031.9	4750.8
CD (0.05)	129.2	324.1	890.1	965.9
SEm ±	44.7	112.2	308.2	334.5

* Days after planting

treatments were on par and significantly higher than T_4 at all the stages. T_2 also recorded higher K uptake at all stages eventhough the difference was statistically superior to T_4 at 60 and 90 DAP only.

4.4.2. Groundnut

4.4.2.1. NPK content of bhusa

The content of NPK in groundnut bhusa was not significantly influenced by levels of N or time of application of N and K to cassava (Table 34).

4.4.2.2. NPK uptake by bhusa

As in the case of NPK content, NPK uptake (Table 34) was also not influenced by levels of N or time of application of N and K to cassava.

4.5. Soil analysis

4.5.1. Total nitrogen

Nitrogen content of soil (Table 35) was significantly influenced by intercropping. Sole cropped cassava had more N content at 30 and 60 DAP and thereafter intercropped cassava had more N content in soil. Levels of N did not show any significant effect on soil N content except at 30 DAP wherein N_2 resulted in higher N content of soil.

Regarding time of application T_1 and T_3 recorded significantly higher N content at 30 and 90 DAP and at harvest. T_3 recorded the lowest N content at all stages

Table 34. NPK content and uptake by bhusa of groundnut

Treatment	Content (%)			Uptake kg/ha		
	N	P	K	N	P	K
Levels of nitrogen						
N_1 56.25 kg ha^{-1}	1.40	0.074	0.64	32.67	1.80	15.15
N_2 75 kg ha^{-1}	1.45	0.071	0.61	36.13	1.86	15.33
CD (0.05)	NS	NS	NS	NS	NS	NS
SEm ±	0.048	0.004	0.024	1.77	0.06	0.69
Time of application (DAP)*						
T_1 (15, 60 and 90)	1.37	0.075	0.592	37.13	1.99	15.93
T_2 (30, 60 and 90)	1.53	0.075	0.65	36.83	1.79	15.55
T_3 (15, 75 and 120)	1.42	0.07	0.63	33.08	1.62	14.99
T_4 (basal, 60 and 90)	1.37	0.08	0.645	30.58	1.74	14.58
CD (0.05)	NS	NS	NS	NS	NS	NS
SEm ±	0.068	0.006	0.034	2.52	0.09	0.98

* Days after planting

Table 35. Total N content (kg/ha) of soil at different stages of growth of cassava.

Treatments	Growth stages (DAP)*				
	30	60	90	120	Harvest
<u>Cropping systems</u>					
S_0 Sole cassava	2434.9	2666.7	2286.7	1993.2	2285.0
S_1 Cassava + groundnut	2130.4	2485.0	2590.0	2432.5	2508.3
CD (0.05)	221.9	163.5	137.6	334.7	145.0
SEm ±	76.87	56.6	47.7	115.9	50.2
<u>Levels of nitfogen</u>					
N_1 56.25 kg ha^{-1}	2078.3	2657.5	2488.3	2286.8	2366.7
N_2 75 kg ha^{-1}	2398.3	2494.2	2488.3	2140.9	2426.7
CD (0.05)	221.9	NS	NS	NS	NS
SEm ±	76.87	56.6	47.7	115.9	50.2
<u>Time of application (DAP)</u>					
T_1 (15, 60 and 90)	2945.0	2585.0	2438.3	2461.7	2741.7
T_2 (30, 60 and 90)	1645.0	2776.7	2298.3	2263.3	2310.0
T_3 (15, 75 and 120)	2723.0	2596.7	2776.7	2146.8	2596.7
T_4 (basal, 60 and 90)	1905.0	2345.0	2240.0	1983.5	1938.3
CD (0.05)	313.9	231.2	194.6	NS	205.1
SEm ±	108.7	80.1	67.41	163.8	71.0

* Days after planting

except at 30 DAP where T_2 had the lower content. T_2 recorded maximum N content in soil at 60 DAP. At 120 DAP the difference in N content of soil was not significant.

4.5.2. Available phosphorus

Significant influence due to intercropping (Table 36) was noticed only at 90 DAP wherein intercropped plot recorded more P content than sole cassava plot. Available P content in soil was not influenced by levels of N.

Regarding the time of application of N and K, it was seen that at 30 DAP T_4 recorded maximum P content in soil whereas at harvest T_1 recorded the highest value. At harvest stage T_2 and T_4 were on par and was lower than T_3.

4.5.3. Available potassium

The effect of intercropping on available K content of soil (Table 37) was significant at 30 DAP only wherein intercropped plots recorded higher values. At 30 and 60 DAP, the K content of the soil was significantly higher for the lower dose of N (56.25 kg ha^{-1}) and thereafter the difference between the N doses was not significant.

Significant difference due to time of application of N and K was obtained only at 30 and 90 DAP. T_2 had significantly lower K content than all other treatments at these two stages except T_4 at 90 DAP.

Table 36. Available phosphorus content of soil (kg/ha) at different stages of growth of cassava

Treatments	Growth stages (DAP)*				
	30	60	90	120	Harvest
Cropping systems					
S_0 Sole cassava	110.6	66.4	56.8	66.1	57.5
S_1 Cassava + groundnut	99.05	73.8	76.8	73.0	62.8
CD (0.05)	NS	NS	15.8	NS	NS
SEm ±	4.03	5.3	5.4	5.34	3.21
Levels of nitrogen					
N_1 56.25 kg ha^{-1}	102.0	71.4	69.7	71.4	56.7
N_2 75 kg ha^{-1}	107.7	67.3	63.9	67.7	63.7
CD (0.05)	NS	NS	NS	NS	NS
SEm ±	4.03	5.3	5.4	5.34	3.21
Time of application (DAP)					
T_1 (15, 60 and 90)	100.0	82.4	74.2	82.7	71.4
T_2 (30, 60 and 90)	125.4	76.5	66.2	77.2	55.9
T_3 (15, 75 and 120)	102.6	65.5	70.3	64.5	64.9
T_4 (basal, 60 and 90)	130.2	63.7	59.5	63.7	48.5
CD (0.05)	NS	NS	NS	NS	13.12
SEm ±	5.7	7.6	7.7	7.55	4.54

* Days after planting

Table 37. Available potassium content of soil (kg/ha) at different stages of growth of cassava.

Treatment	Growth stages (DAP)*				
	30	60	90	120	Harvest
Cropping systems					
S_0 Sole cassava	576.6	602.0	590.0	461.3	865.4
S_1 Cassava + groundnut	565.4	638.3	626.6	475.0	901.25
CD (0.05)	NS	30.6	NS	NS	NS
SEm ±	10.92	10.6	30.47	20.09	17.4
Levels of nitrogen					
N_1 56.25 kg ha^{-1}	590.0	637.9	611.3	455.4	891.25
N_2 75 kg ha^{-1}	552.0	602.5	605.4	480.8	875.4
CD (0.05)	30.68	30.6	NS	NS	NS
SEm ±	10.92	10.6	30.47	20.09	17.4
Time of application (DAP)					
T_1 (15, 60 and 90)	643.3	621.6	635.9	524.1	915.8
T_2 (30, 60 and 90)	458.3	681.6	496.7	489.9	906.6
T_3 (15, 75 and 120)	661.6	656.6	712.6	438.3	868.3
T_4 (basal, 60 and 90)	578.3	659.3	588.6	420.8	842.5
CD (0.05)	44.62	NS	124.5	NS	NS
SEm ±	15.42	15.02	43.09	82.08	24.6

* Days after planting

when these two treatments were on par. T_3 had the highest K content at 90 DAP and was on par with T_1.

4.5.4. Land Equivalent Ratio (LER)

LER presented in Table 39, showed that there was no significant difference due to treatments or interactions. However, a trend was seen wherein, when cassava alone was considered T_3 had given more LER under both the levels of N. With reference to groundnut no definite trend was seen. When the combined effect of crops were taken into consideration maximum LER was observed in T_1 under both the levels of N.

Table 38. Land Equivalent Ratio

La (Cassava)

	T_1	T_2	T_3	T_4	Mean
N_1	1.17	1.0	1.20	0.95	1.08
N_2	1.07	1.06	1.16	0.97	1.05
Mean	1.12	1.03	1.18	0.96	

Lb (Groundnut)

	T_1	T_2	T_3	T_4	Mean
N_1	0.49	0.61	0.41	0.51	0.51
N_2	0.47	0.44	0.41	0.54	0.47
Mean	0.48	0.52	0.41	0.53	

LER = La + Lb

	T_1	T_2	T_3	T_4	Mean
N_1	1.66	1.61	1.61	1.46	1.59
N_2	1.54	1.50	1.57	1.51	1.52
Mean	1.60	1.57	1.59	1.49	

SEm $\pm$ N - 0.064
T - 0.004
N x T- 0.005

Discussion

DISCUSSION

The results of the experiment to study the effect of intercropping with groundnut, levels of N and time of application of N and P on growth and yield of cassava and groundnut and quality of cassava are discussed in this chapter. The effect of the treatment on nutrient uptake by the crops are also detailed.

5.1. Growth characters

5.1.1. Cassava

5.1.1.(1) Number of leaves

The results showed that there was no significant increase in the number of leaves produced by cassava due to growing groundnut as an intercrop. However, at early stages and at 180 days stage there was a slight increase. The N supplied by way of groundnut intercropping might not be sufficient to augment the leaf production to a significant extent.

Cassava with higher levels of N (75 kg ha^{-1}) had produced more leaves and from 60 days onwards this effect was significant. Nitrogen, in general enhances the vegetative growth of the plant and thus resulted in more leaf production. Up to 90 days the growth of plant was slow and the amount of N at the level of 56.25 kg ha^{-1} might have been sufficient for the optimum growth. After about three months from planting the growth rate of cassava is faster and the requirement of N will be higher. This might be the reason for a significant response to N application after 90 DAP. Ramanujam and Indira (1979) and Prabhakar et al. (1979) also reported higher rate of leaf production with higher levels of N.

When the 1st dose of fertiliser was applied at 15 DAP (T_1 and T_3), the leaf production was invariably higher. The stakes, after planting, require about 15 days to sprout and produce active roots (Onwueme, 1977). Therefore postponing the basal application of N and K till the roots are produced would be beneficial for getting higher response for the nutrients applied. This is particularly relevant in the higher rainfall conditions like the one prevailed during the experimental period where about 77 mm of rainfall was obtained during the first two weeks after planting (Appendix I). The net loss due to leaching under such situation must be very high and substantial quantity of the applied nutrient, particularly N would have been lost before the formation and growth of the absorbing roots. This must be the reason for the better performance of these two treatments over the control where the fertiliser was applied basally. On the other hand in T_2 where the fertiliser was applied only 30 DAP the initial growth of the cassava plants were affected due to want of N at sprouting stage (15 DAP).

5.1.1.(ii) Height of plant

It was observed from the Table 2 that there was no significant effect on height of cassava due to intercropping at early stages of growth. However intercropped cassava recorded more height than sole cassava at later stages. This might be due to the beneficial effect of legumes in enriching the soil nitrogen. Similar results of increased height in cassava intercropped with groundnut were obtained by Prasad and Choudhary (1975) and Bhat (1978).

N at the level of 75 kg ha^{-1} resulted in taller plants and difference was significant at the time of harvest. Krochmal and Samuels (1970) reported that higher levels of N tended to increase the height of cassava. This was also in agreement with the results obtained by Pillai and George (1978).

As in the case of number of leaves T_1 and T_3 produced plants with more height than T_2 and T_4 and response could be attributed to the same reason as explained earlier.

5.1.1.(iii) Girth of stem

Girth of stem (Table 3) was not influenced by intercropping and levels of N. All the nutrients applied to sole cassava was available to cassava plants alone whereas in intercropped cassava a fraction of the nutrient might have been utilised by the intercrops for its growth especially during their initial growth. This might have contributed to higher girth of tapioca plants eventhough not significant during early stages. However after initial growth, the groundnut plants would produced root nodule and started nitrogen fixation which consequently reduce the competition with cassava for soil nitrogen. So also when the bhusa was incorporated after harvest more nitrogen was made available to the cassava plants which resulted in better growth of cassava in intercropped plot. This might be the reason while there was no significant difference between the girth of intercropped and sole cropped cassava at harvest stage.

As in the case of number of leaves and height of plant, the girth of stem was also significantly affected by time of application of N and K persumably due to the reason already stated.

5.1.1.(iv) Canopy spread

Intercropping cassava with groundnut and higher level of N tended to increase the canopy spread of cassava eventhough the difference was not significant. Better canopy spread of intercropped cassava towards the later stages is an indication of the beneficial effect of groundnut by way of nitrogen enrichment by excretion from the nodules and by the decomposition of the incorporated bhusa.

The higher level of N also resulted in the better growth of the plants that produce bigger leaves and resulted in more spread of the canopy.

T_1 and T_3 treatments in general resulted in higher canopy spread which must be due to the better utilisation of fertilisers which were supplied at the time when the roots were produced (15 DAP) as already discussed.

5.1.1.(v) Leaf area index and net assimilation rate

The leaf area index and net assimilation rate of cassava was not very much influenced by intercropping with groundnut. Nitrogen application in general showed a favourable effect on these two characters probably due to the beneficial effect of N on enhancing the production of leaves (Table 1) and dry matter accumulation.

The common practice of basal application of N and K resulted in lower LAI and NAR than the other treatments where the 1st dose was delayed by 15 or 30 days. This indicates that N applied at or after the formation of roots on the stakes was more efficiently utilised for producing more number of leaves (Table 1) and thereby more dry matter accumulation which ultimately resulted in more LAI and NAR.

5.1.2. Groundnut

5.1.2.(i)Height

Height of groundnut plant was not significantly influenced by the levels of N whereas the time of applicatior of N and K to cassava had a significant effect. Maximum height was recorded by T_4 where the 1st dose of fertiliser was given as basal. In the case of leguminous intercfops it takes sometime for the plants to obtain nitrogen by symbiotic fixation (Jain, 1975). During the initial stages of growth plant requires some amount of nutrients and is mainly obtained through added fertilisers (Schandert, 1943). As in the case of T_4 this initial requirement could be met from the basal dose of N applied to cassava whereas in all the other treatments as the 1st dose was applied at either 15 or 30 DAP, the groundnut plants suffered for want of starter dose of nitrogen and thus resulted in lower height. As there is no significant differences between the two doses it seems that the requirement of N for groundnut is not very high. Less competition consequent to less vigorous growth of cassava (Table 1,2 and 3) might have also contributed to this trend. Increase in height of groundnut due to fertiliser application have been reported by Bhat (1978).

5.1.2.(ii) Leaf area index

LAI was not influenced by levels of N or time of application of N and K to cassava eventhough T_2 and T_4 had given more LAI. In T_2 and T_4 the early growth of cassava was poor. This resulted in better utilisation of nutrients, space and sunlight by groundnut and which in turn resulted in better leaf production and more LAI.

5.2. Yield attributes and yield

5.2.1. Cassava

5.2.1.(i) Number of tubers per plant

From the results (Table 8) it was observed that intercropping cassava with groundnut was significantly superior to sole cassava with respect to number of tubers per plant. As the recommended amount of nutrients were applied to the groundnut there would not have been any serious competition for nutrients with cassava. At the same time more nutrients were added to the soil by way of incorporating the bhusa which would have helped the cassava to produce more tubers. Bhat (1978) also observed a similar trend when cassava was intercropped with groundnut.

The increase in tuber number in cassava may also be due to the stimulation of root primodia by the nitrogen excreted from the legumes (Russel, 1973) or the enrichment of soil nitrogen by the incorporation of bhusa into the soil (Singh et al. 1969); Nitis and Sumatra (1976).

Time of application of N and K had significant influence on number of tubers and T_1 produced maximum number followed by T_3. In T_1, the fertiliser was applied at 15, 60 and 90 DAP and in T_3 it was given at 15, 75 and 120 DAP both resulted in better utilisation of applied nutrients since the crop might have developed its root system only by about 15th day. Onwueme (1977) noted that cassava stakes takes about 15 days to establish a well developed root system. Ashokan and Nair (1982) also obtained maximum efficiency of N and K when applied at 15, 60 and 90 DAP. In T_4, which is the present practice of recommendation, much of the nutrients might have been lost by leaching in heavy rainfall (Appendix I), before the roots were produced. On the contrary in T_2 where the fertiliser was applied at 30 DAP, vegetative growth of the crop was poor due to inadequate supply of nutrients at the initial stages of growth which ultimately resulted in less tuberisation. Indira and Kurian (1973, 1977) noted that tuberisation of cassava began 21 days after planting when the roots themselves were only about 10 days old.

5.2.1.(ii) Size of tuber

Length and girth of tuber are discussed here. Length of the tuber (Table 9) was increased by intercropping. This would be due to the beneficial effect of the legumes and the bhusa incorporation on the root development of cassava. Nitis and Sumatra (1976) and Bhat (1978) also obtained similar increase in tuber length due to legume intercropping. Girth of tuber (Table 10) tended to increase by intercropping cassava with groundnut as compared to sole cassava. Bhat (1978) reported that intercropping of legumes resulted in increased tuber girth of cassava. After the harvest of the intercrop, bhusa was incorporated insitu and this would have resulted in increased availability of N and K as indicated by the higher uptake of N and K (Table 23, 33) by cassava. This increased availability of nutrient might have also resulted in increased tuber girth. Increase in tuber girth by application of N and K was reported by Natarajan (1975) and Thampan (1979).

T_3 and T_1 showed higher tuber length and girth than the other treatments. This must be due to the better utilisation of fertilisers as discussed earlier. More over in T_3 the last dose of N and K was given at 120 DAP which resulted in more uptake of added nutrients (Table 23, 33). It is evident from the results that cassava responds to application of fertilisers even after three months stage. Gomes et al. (1981) obtained a similar increase in tuber size with application of N upto 150 DAP. Ashokan and Sreedharan (1977) also noted the same increase in tuber size with application of K upto three months after planting. The rapid bulking of tubers continues upto the period of eight months stage or above (Singh et al. 1970 and Thampan, 1979). Obviously the crop can utilise larger quantities of plant nutrients from the soil during this period. The favourable influence of major nutrients in the synthesis of starch and consequent accumulation of it in the tubers would have caused the increase in girth of tuber. This calls for further investigation on time of application of N and K even after 90 days of planting.

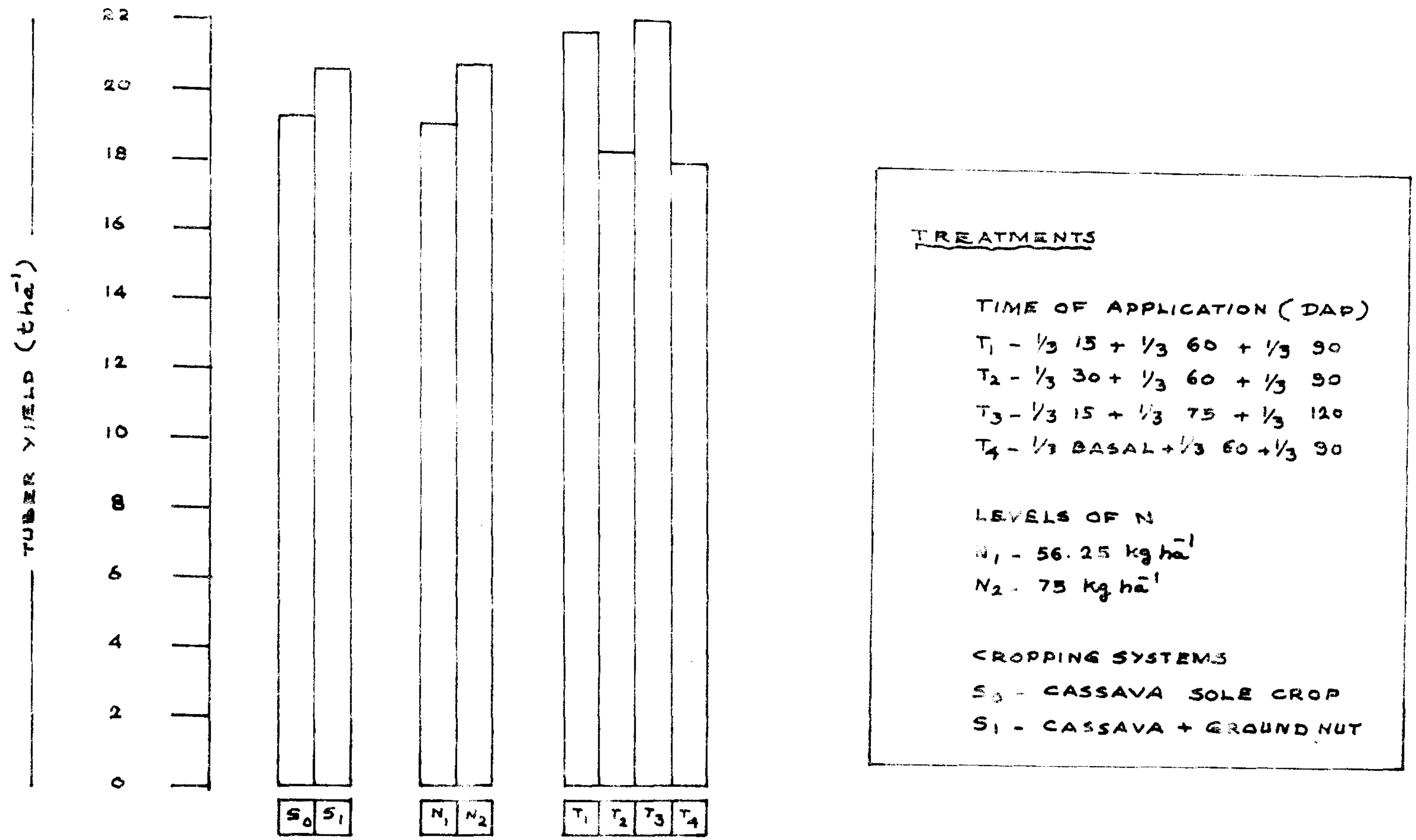
5.2.1.(iii) Tuber yield

The yield of tapioca tuber (Table 11 and Fig. 2) was significantly higher in the intercropped plot as compared to the sole cropped plot. This can be attributed to the increased length, girth and number of tubers (Table 8,9 and 10) in intercropped plots. An increase in tuber yield was obtained when short duration leguminous crops were raised in cassava by Bhat (1978) and Nambiar et al. (1979). In intercropped cassava the chances for increased rate of photosynthesis were more due to greater leaf number (Table 1) and consequently the higher leaf area. Thus the photosynthate so produced would have been translocated and accumulated leading to a significant increase on tuber yield.

Higher levels of N also increased the tuber yield in cassava. As discussed earlier this again is brought about by the favourable effects of N on the yield attributes (Table 8,9 and 10). The higher leaf area produced in plots with higher level of N also would have resulted in more accumulation of photosynthates in the tuber.

Among the time of application treatments T_1 and T_3 were significantly superior to T_2 and T_4 and the former were on par. This indicates the proper timing of

FIG. 2 TUBER YIELD OF CASSAVA AS INFLUENCED BY CROPPING SYSTEM, LEVELS OF N AND TIME OF APPLICATION OF N AND K



fertiliser application for getting maximum benefits. The reason attributed to this might be same as discussed earlier.

In N x T interaction T_1 and T_3 at higher level of N (N_2) was significantly superior to T_1 and T_3 at lower level (N_1). It may also be seen from the results that N_2T_4 and N_2T_2 have recorded significantly lower yield. The higher dose of N applied basally might not have been taken up by the cassava as it might be leached down before effective root formation. On the other hand a delayed application also is not benefitted fully as the crop had already suffered for want of N during its early growth period. Ashokan and Nair (1982) also advocated three split application of N and K at 15, 60 and 90 DAP in heavy rainfall areas so as to reduce the nutrient loss by leaching and to increase the efficiency of utilisation of applied nutrients.

With reference to the S x T interaction it is seen that S_1T_3 recorded the maximum yield which was significantly superior to all other combinations except S_1T_1. In this treatment the last dose of N and K was applied at 120 DAP which was after the harvest of the groundnut at 110 days. So the entire quantity of 3rd dose of fertiliser was available for cassava without any competition from groundnut. Thus it gives an indication that for better yields the last dose of N and K fertiliser should be applied to cassava after the harvest of intercrops. The combination S_1T_4 had given significantly lower yield than S_0T_4. This shows that when the N and K are given as basal under the intercropped situation, the main crop yield is lesser probably due to the reason that some of the applied nutrients must have been taken by the intercrop as well. This calls for some change in the present recommendation for the cassava-groundnut intercropping system wherein the fertiliser is given at 30 DAP. Hence the final recommendation should be such that the application of N to the leguminous intercrops should be given as basal and for the maincrop it should be at 15 DAP. The 2nd dose of fertiliser to the maincrop can be given at 60 or 75 DAP and the 3rd dose of fertiliser should be given after the harvest of the groundnut.

Higher level of N had invariably increased the yield of tapioca irrespective of the intercropping with groundnut. The analysis of S x N interaction showed that S_1N_1 was on par with S_0N_2. This shows that under intercropped condition lower level of N (56.25 kg ha^{-1}) is sufficient to produce the same yield obtained with 75 kg N ha^{-1} under sole cassava. Thus for similar yields just by intercropping cassava with groundnut ¼th of the fertiliser N can be saved. This is in addition to the yield obtained from the intercrop without any adverse effect on the main crop. It may also be noted that S_1N_2 is significantly superior to S_0N_2. This signifies that along with intercropping application of N at the recommended level has further boosted the yield to a significant level.

Therefore it is to be summarised that intercropping of groundnut with cassava is beneficial. For intercropped situation the best time of application is T_3 ie., 15,75 and 120 DAP. The addition of full dose of N to the main crop always gives maximum production along with intercropping. Hence intercropping with 100 per cent of fertiliser N is ideal for maximum yield.

As far as the sole crop situation is concerned, the conclusions on N,K fertilisers are (a) the basal application should be shifted to 15 DAP, (b) the second dressing may be given either at 60 or 75 DAP, (c) the third application may be given either at 90 or 120 DAP.

5.2.2. Groundnut

5.2.2.(i) Pod yield

Pod yield in groundnut (Table 13) is influenced by levels of N and time of application of N and K to cassava. It was observed that when the quantity of N applied to cassava was more (100 per cent) yield of groundnut was reduced. As groundnut is a leguminous crop capable of fixing N for its needs additional application of N usually enhance the growth of foliage (Table 14) in preference to pod formation. Here also eventhough the

N was applied to mounds of cassava much of it would have been leached down by heavy rainfall prevailed during crop season and would have been available to the groundnut.

Among the different time of application T_1 and T_3 recorded lower pod yields than T_2 and T_4. It may be mentioned that the growth especially canopy spread of cassava was more in T_1 and T_3. This in turn would have reduced the availability of sunlight to groundnut by shading leading to more foliage growth in groundnut.

5.2.2.(ii) Bhusa yield

Bhusa yield of groundnut was not significantly influenced by the treatments. However the bhusa yield was higher with the higher level of N and for the treatments T_1 and T_3. This must be due to the reasons already pointed out.

5.3. Quality attributes of cassava

5.3.1. Dry matter content of tuber

The results (Table 15) showed that the treatments did not have any significant influence on dry matter content of tubers. Sheela (1982) also did not obtain any significant difference in dry matter content of tubers due to intercropping in cassava.

Levels of N and time of application of N and K also tended to increase the dry matter content of tuber though the difference were not significant. Higher level of N (75 kg ha^{-1}) at T_1, T_2 and T_3 had more dry matter than lower level of N. Increased dry matter content of tuber due to nitrogen fertilisation was reported by Pillai (1967), Vijayan and Aiyer (1969) and Mandal et al. (1971). Higher dry matter content is attributed to the better utilisation of added fertilisers as discussed earlier.

5.3.2. Starch content of tuber

From the results (Table 17) it was observed that the percentage of starch in tapioca tuber was significantly increased by intercropping with groundnut. This might be due to the enrichment of soil N by the legume (Table 35), which had resulted in better growth of cassava resulting in more carbohydrate synthesis. Similar results on cassava due to intercropping legumes have been reported by Bhat (1978) and Sheela (1982).

The starch content of cassava tuber was increased by higher level of N. This increase in starch content due to N application is in agreement with the results of Pillai (1967) and Ramanathan et al. (1981).

Time of application of N and K also showed a significant influence on starch content. T_1 and T_3 recorded more starch content than T_2 and T_4. This might be due to the higher uptake of K (Table 33) and better utilisation of K by cassava from these treatments.

Increase in starch content of cassava tuber with increased availability of K has been reported by Mandal et al. (1968), Kumar et al. (1971), Obigbesan (1973) and Ashokan and Sreedharan (1977).

5.3.3. Crude protein content of tuber

As seen from the Table 18 the crude protein content of cassava tuber was increased by legume intercropping, eventhough not significant. This can be attributed to the higher N availability in soil due to intercropping of groundnut (Table 35).

Higher level of N (75 kg ha^{-1}) significantly increased the crude protein content of tuber. Such an increase in protein content of cassava by N application have been noted by many workers (Malavolta et al. 1955; Pillai, 1967; Pillai and George, 1978; Gomes and Howler, 1980 and Muthuswamy and Rao, 1981).

Tuber from the plots in which the 1st dose of fertiliser was applied at 15 DAP (T_1 and T_3) had significantly higher crude protein content than other two treatments. From the data on the influence of different treatments on N uptake by the crop (Table 23) it could be seen that these treatments recorded higher uptake which in turn might have increased the crude protein content.

5.3.4. Hydrocyanic acid content

The HCN content of tuber (Table 19) showed no significant difference due to treatments. However, there was an increasing trend in HCN content with legume intercropping and higher N application. It has been observed in many previous studies (Pillai, 1967; Kumar et al. 1971; Prema et al. 1975 and Sinha and Indira, 1968), that the HCN content of cassava tuber will be increased with addition of N. So it is quite natural that in this study also there was higher HCN content at the higher level of N. The legume intercropping also tended to increase the HCN content because of its effect in enriching the soil N (Table 36). Such effects due to legume intercropping has been reported by Bhat (1978) and Sheela (1982).

The interaction S x N is significant probably because of the enhanced effect of intercropping and N application.

5.4. Plant analysis

5.4.1. N content of leaf, petiole and stem

Intercropping did not show any significant influence on the N content of leaf, petiole and stem at most stages of growth (Table 19, 20 and 21). However N content in the leaves of cassava from intercropped plots always showed a higher value. Usually maximum quantity of N taken up by the crop is present in the leaves (Krochmal and Samuels, 1970; Kanapathy, 1974; and Thampan, 1979). The difference in the higher N content of cassava can be attributed to N enrichment of soil by the legume as seen from the data on soil analysis (Table 35).

As expected, higher levels of N recorded higher N content in leaf and petiole at all stages. Similar results have been reported by Kanapathy (1974) and Muthuswamy (1978).

Among the time of application treatments T_3 and T_1 recorded higher N content in all parts at harvest stage than T_2 and T_4. This might be due to the better utilisation of applied N in these treatments where the application of first dose of N (15 DAP) coincided with the emergence of the roots. As already discussed much of N applied basally in T_4 would have been lost by leaching before the crop produced its roots. On the other hand the initial crop growth would have been adversely affected due to insufficient supply of N in treatment T_2 where the first dose was given only at 30 DAP.

Nitrogen content in plant parts at different stages of growth is directly related to time at which the fertiliser was supplied. Thus, T_2 where the N was applied at 30 DAP showed higher N content in leaf than when the first dose was applied at an early date (basal or 15 DAP). Similarly at 90 days stage, T_3, where the second dose was given at 75 DAP recorded higher N content in all parts compared to the other treatments where the second dose was given at 60 days stage.

5.4.2. Tuber N content

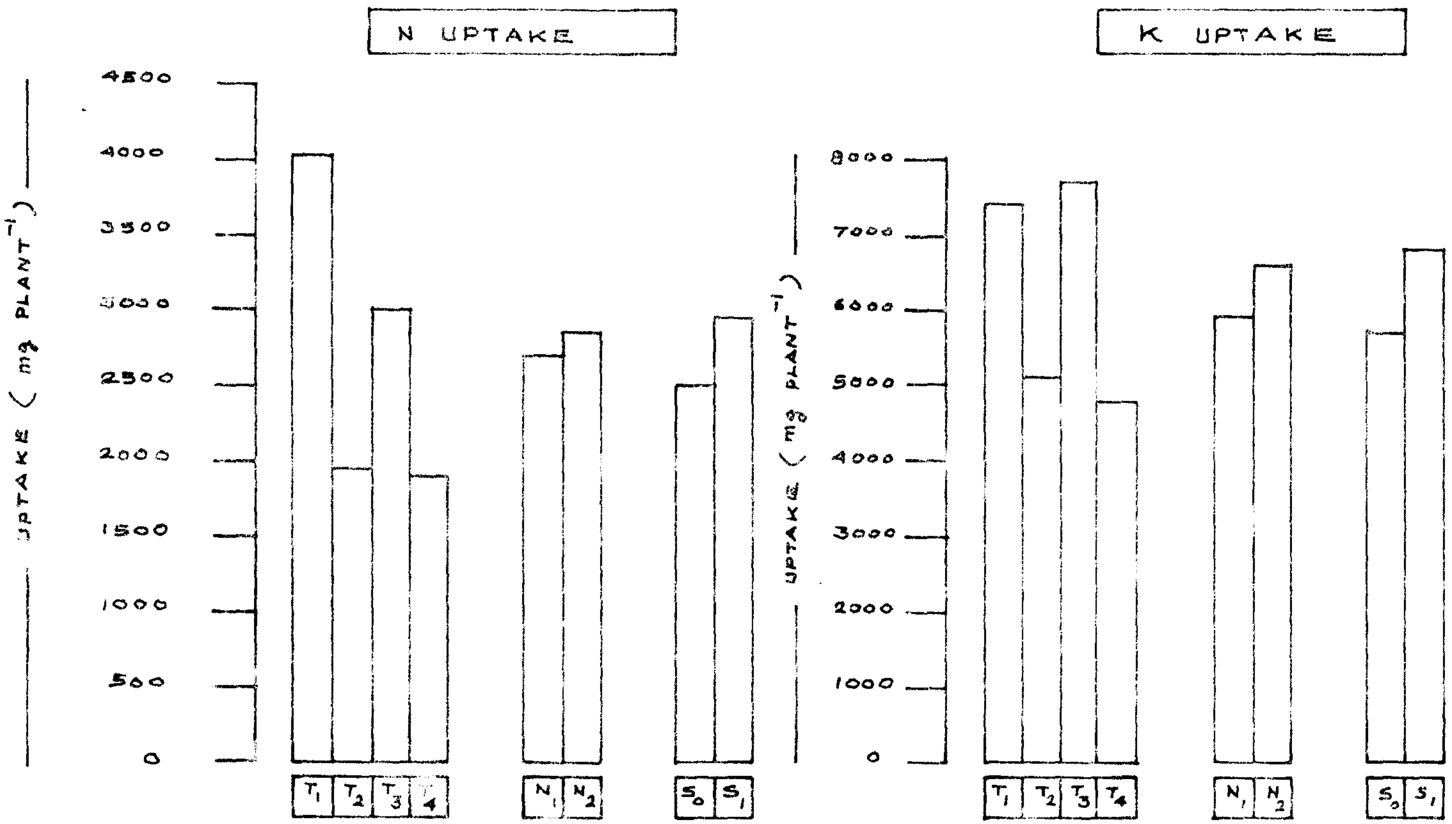
N content in tuber was higher in intercropped plots even-though the difference was not significant at harvest stage. This is persumably due to the N enrichment by the legume and is in agreement with the findings of Sheela (1982). When the quantity of N applied was more the N content of the tuber was also more. Many workers have reported similar observations (Malavolta et al. 1955; Pillai, 1967; Hukkeri, 1968; Pillai and George, 1978; Gomes and Howler, 1980 and Muthuswamy and Rao, 1983).

Among the time of application T_3 and T_3 resulted in significantly higher N content at harvest. This can be attributed to the better utilisation of applied fertilisers as already discussed in these treatments.

5.4.3. N uptake

Results presented in Table 23 and Fig. 3 indicated that intercropping resulted in a higher N uptake by cassava eventhough the effect was not significant at all stages. This is due to the higher N content in different plant parts due to intercropping with groundnut (Table 19, 20, 21 and 22) and also due to the better growth and yield (Table 11), of cassava. Similar results of higher N uptake by cassava intercropped with legumes have been reported by Sheela (1982).

FIG: 3 N AND K UPTAKE BY CASSAVA AS INFLUENCED BY INTERCROPPING, LEVELS OF N AND TIME OF APPLICATION OF N AND K



TREATMENTS

LEVELS OF N

N_1 - 56.25 kg ha^{-1}

N_2 - 75 kg ha^{-1}

CROPPING SYSTEMS

S_0 - CASSAVA SOLE CROP

S_1 - CASSAVA + GROUND NUT

TIME OF APPLICATION (DAP):

T_1 - 1/3 15 + 1/3 60 + 1/3 90

T_2 - 1/3 30 + 1/3 60 + 1/3 90

T_3 - 1/3 15 + 1/3 75 + 1/3 120

T_4 - 1/3 BASAL + 1/3 60 + 1/3 90

Higher level of N also increased the N uptake by cassava at harvest eventhough not significant. This is usually expected because higher N application will result in better growth, yield and N content of the crop. Increase to N uptake by cassava with higher dose of N was reported by Thampan (1979).

Among the time of application treatments, T_1 and T_3 have given higher N uptake at harvest. It may be recalled that these treatments had a higher N content in different plant parts and higher yield (Table 11) which are the two components effecting the N uptake. At the earlier stages the treatments had different effects.

5.4.4. P content of cassava leaf, stem, petiole, tuber and P uptake

Phosphorus content of leaf, petiole, stem and tuber and P uptake were not generally influenced by any of the treatments or treatment combinations at most of the stages. However, the P uptake by the crop at harvest was significantly higher for the treatments T_1 and T_3. As there is no marked difference in the P content of plant parts this result can be attributed to the higher yield of the crops.

5.4.5. K content of cassava leaf, petiole, stem and tuber and K uptake

K content in cassava leaves was significantly higher in intercropped plot at harvest stage. Similar was noticed in stem and tuber as well. The uptake of K (Fig. 3) was also higher at all stages in intercropped plot and it was significant at 90 DAP and at harvest stage. It might be seen from the Table 11 that the yield of tapioca was higher in intercropped plot which might have resulted in an increased uptake of K. K content in the stem and tuber were not seen influenced by levels of N.

Higher dose of N however increased the uptake of K. Many workers have reported increased K uptake by N fertilisation in cassava (Rajendran et al., 1976; Muthuswamy, 1978; Mohankumar and Nair, 1979 and Sathianathan, 1982).

At harvest stage the K content was higher in leaf, petiole, stem and tuber for the treatments T_1 and T_3. In the total uptake of K also these treatments recorded the maximum value. This may be attributed to the better growth and yield recorded in them.

5.4.6. NPK content and uptake by bhusa

These characters (Table 34) were not influenced by any of the treatment or their combinations, the notable reason being that the bhusa yield was influenced by them.

The quantity of nutrient absorbed by groundnut was probably not sufficient to exert a significant change in the content as well as the uptake, since the fertiliser applied would have been washed away from the root zone of the crop.

5.5. Soil analysis

5.5.1. Total nitrogen

There was a significant difference due to intercropping in soil N content. At early stages of growth (30 and 60 DAP) sole cropped plot showed more N content than intercropped plot. In the case of leguminous crops it takes sometime for the plants to obtain nitrogen by symbiotic fixation (Jain, 1975). During the initial stages of growth plants have to depend on fertiliser N for growth (Schandert, 1943) and so part of the nutrient applied to the cassava was taken by the intercrop for early growth.

The intercropped plot had more N content in soil particularly at 120 DAP and at harvest. This increase in N content of the intercropped plot at later stages may be due to the enrichment of soil N by the groundnut by N fixation in the nodules and by the incorporation of bhusa. Enrichment of soil N by leguminous intercrops in tapioca has been reported by Singh et al. (1969), Bhat (1978) and Sheela, (1982).

As to the time of application it might be seen that T_1 treatment had more N content at later stages of growth especially at harvest. It might be recalled that the bhusa yield was mofe in this treatments and naturally incorporation of the same must have increased the N content of the soil.

5.5.2. Available P

The available P content of soil was not generally influenced by intercropping or levels of N but time of application (T_1) had significantly influenced the P content of soil particularly at harvest stage. In T_1, the higher bhusa production must have resulted in higher uptake of P by bhusa which upon incorporation would have helped to increase the P content of the soil.

5.5.3. Available K

Available K content of the soil (Table 37) was not influenced by intercropping or level of N. Time of application of K showed significant difference at 30 and 90 DAP. At 30 DAP T_2 had the least K content in the soil, since it has not received K by then. But 90 DAP T_3 had more K content in the soil as the 2nd dose of fertiliser K was given at 75 DAP. At the time of harvest, time of application of N and K did not show any significant effect on available K content of soil. Easily leachable nature of mobile K^+ ions may be attributed to this insignificant effect.

5.5.4. Land Equivalent Ratio (LER)

The results presented in Table 39 showed that the LER of cassava was maximum in plots which receiving

N and K at T_3 ie., 15, 75 and 120 DAP. A reference to the yield Table 11 showed that cassava had given maximum yield under this treatment. The least LER was recorded in T_4. This shows that time of application of N and K has some influence in increasing the LER also under sole crop situation.

As regards to groundnut no definite trend is seen in LER values.

With regards to the combined effect of cropping it may be seen that T_1 has recorded maximum values under both the levels of N.

5.5.5. Economics of intercropping

Economics of intercropping worked out is presented in Table 39 and Fig. 4. It was seen that under both the levels of N maximum profit was recorded in T_3 for the cassava crop (Col. 5). When the sole crop of cassava is taken into account (Col. 8) T_3 has given the maximum profit in 75 per cent N and T_1 in 100 per cent N. Total increase (Col. 7) and benefit/cost ratio (Col. 9), where highest in intercropped situation under T_3, both at 75 per cent N and at 100 per cent N levels. This shows that intercropping cassava with groundnut is definitely advantageous from the point of view of economics.

Table 39. Economics of intercropping

Treatments		Cost of cultivation (Rs ha^{-1})		Total income (Rs ha^{-1})				Benefit* cost ratio	
				Intercropped cassava					
Levels of nitrogen (1)	Time of application of N and K (DAP) (2)	Intercropped plot (3)	Sole cassava (4)	Cassava (5)	Groundnut (6)	Total (7)	Sole cassava (8)	Intercropped cassava (9)	Sole Cassava (10)
75 % N (56.25 kg ha^{-1}) + 75 kg P_2O_5 + 75 kg K_2O	T_1(15,60 and 90)	7106.8	6066.8	16277.5	4676.25	20953.75	13890.00	1.94	1.27
	T_2(30,60 and 90)	7106.8	6066.8	13633.75	5154.75	18788.50	13515.00	1.64	1.23
	T_3(15,75 and 120)	7106.8	6066.8	17203.75	3864.25	21068.00	14280.00	1.95	1.35
	T_4(basal,60 and 90)	7106.8	6066.8	13648.75	5894.25	19543.50	13451.25	1.75	1.22
100 % N (75 kg ha^{-1} + 75 kg P_2O_5 + 75 kg K_2O	T_1(15,60 and 90)	7219.8	6179.8	17286.75	3750.00	21036.75	16817.25	1.91	1.72
	T_2(30,60 and 90)	7219.8	6179.8	14458.5	5198.50	19657.00	13281.00	1.72	1.15
	T_3(15,75 and 120)	7219.8	6179.8	17458.5	3937.00	21395.50	16600.00	1.96	1.69
	T_4(basal,60 and 90)	7219.8	6179.8	13260.0	4638.00	17898.00	14152.50	1.47	1.29

Cost of cassava .. Rs. 0.75/kg

Cost of groundnut .. Rs. 5/kg

Cost of urea .. Rs. 2.30/kg

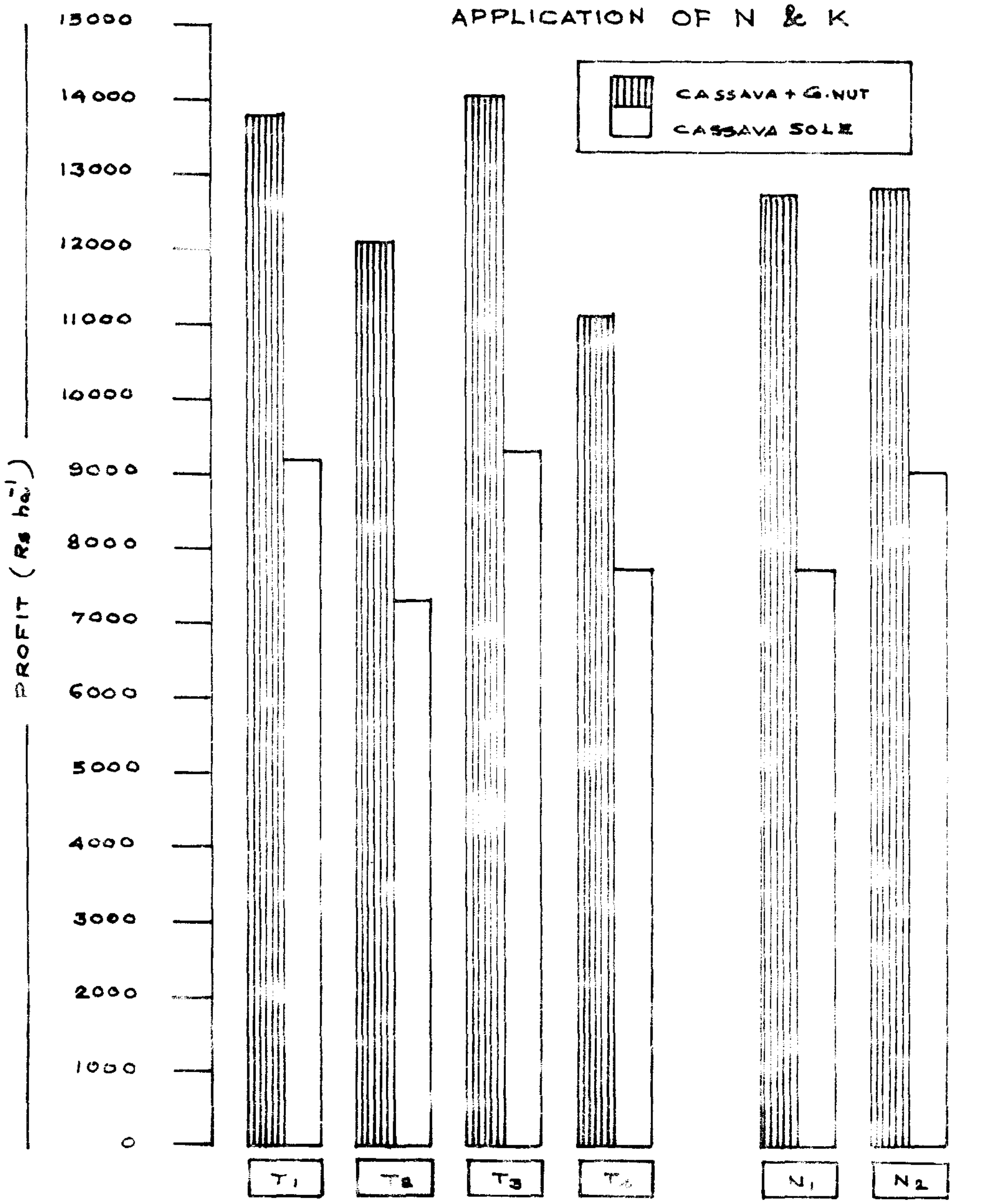
Cost of superphosphate .. Rs. 1.05/kg

Cost of MOP .. Rs. 0.85/kg

* Benefit - Net Profit (Rs.)

Cost - Cost of Cultivation.

FIG: 4 ECONOMICS OF INTERCROPPING AS INFLUENCED BY DIFFERENT LEVELS OF N AND TIME OF APPLICATION OF N & K



T – TIME OF APPLICATION (DAP)

T_1 – 1/3 15 + 1/3 60 + 1/3 90

T_2 – 1/3 30 + 1/3 60 + 1/3 90

T_3 – 1/3 15 + 1/3 75 + 1/3 120

T_4 – 1/3 BASAL + 1/3 60 + 1/3 90

N – LEVELS OF NITROGEN

N_1 – 56.25 kg ha^{-1}

N_2 – 75 kg ha^{-1}

Summary

SUMMARY

An experiment was conducted at Agricultural Research Station, Mannuthy, to study the effect of levels of N and time of application of N and K in a cassava -groundnut intercropping system. A 2 x 2 x 4 factorial experiment with two cropping systems (cassava with and without groundnut), two levels of N (75 per cent and 100 per cent of the recommended dose) and four time of application of N and K (T_1-15, 60 and 90 DAP; T_2 - 30, 60 and 90 DAP; T_3 - 15, 75 and 120 DAP; T_4 - basal 60 and 90 DAP). The experiment was laid out in Randomised Block Design with three replications and the results of the investigation are summarised below:

1. The morphological and physiological growth parameters of cassava such as number of leaves, height and girth of stem, canopy spread, LAI and NAR were enhanced by intercropping as well as 100 per cent recommended dose of N.

2. Intercropped cassava had more number as well as length of tuber than sole cassava. Treatments receiving the 1st dose of fertiliser at 15 DAP were superior to either basal or late application. Hundred per cent recommended dose of N enhanced the tuber girth appreciably.

3. Intercropping cassava with groundnut significantly

increased the tuber yield and utilisation index of cassava. Hundred per cent recommended dose of N recorded higher yield than 75 per cent recommended dose.

4. Plots receiving 1^{st} dose of fertilizer at 15 DAP had produced significantly higher yield than plots which received the 1^{st} dose either as basal or at 30 DAP. It was also seen that intercropping groundnut could save 25 per cent of recommended dose of fertiliser N. However, 100 per cent recommended dose with groundnut intercropping gave still more higher yields of cassava.

5. Intercropping cassava with groundnut increased the starch content of tuber. Application of 100 per cent recommended dose of N and the treatments receiving the 1^{st} dose of N and K at 15 DAP also recorded higher starch content.

6. The crude protein content of cassava was increased by intercropping with groundnut. This was also more in plots receiving 100 per cent recommended dose of N and application at 15 DAP.

7. N uptake by cassava was significantly more in intercropped plots. Skipping the basal dose and applying at 15 DAP gave higher N uptake. Hundred per cent N recorded more N uptake at all stages of growth.

8. P uptake was not influenced by intercropping and levels of N. The treatments receiving 1st dose at 15 DAP recorded more P uptake.

9. Intercropping cassava with groundnut increased the K uptake. Hundred per cent N also favourably enhanced the same. The plots receiving N and K at 15 DAP recorded higher uptake.

10. The yield of groundnut was significantly higher at lower level of N.

11. At 30 DAP soil N was more in sole cassava treatment. Application of 100 per cent N and N and K at 15 DAP recorded higher soil N. P and K were not influenced by the treatment at this stage.

12. At 60 DAP soil N was more in sole cropped plot. P content was not influenced by any of the treatments. Soil K was more in intercropped plot.

13. At 90 DAP soil N was more in intercropped plots and in plots received N and K at 15 DAP. Soil P was not influenced by any of the treatments. Soil K was increasing by intercropping with 100 per cent N and by N and K application at 15 DAP.

14. Intercropping and N and K dressing at 15, 60 and 90 DAP recorded more soil N and K at 120 DAP. Soil P was not influenced by any of the treatments. Soil K was more in intercropped plots receiving 100 per cent N while soil N was more in 75 per cent dose of N.

15. At harvest soil N was increased by intercropping, application of 100 per cent N increased soil N while N and K fertiliser dressing at 15 DAP, enhanced both soil N and P. Soil K was not influenced by any of the treatments.

16. Application of N and K fertilisers at 15, 75 and 120 DAP recorded the maximum LER values in sole crop of cassava while under the intercropped situation it was maximum in plots received N and K at 15, 60 and 90 DAP.

17. Maximum income was recorded by N and K application at 15, 75 and 120 DAP of the intercropped cassava under both the levels of N. Total income was also more in the same treatments.

Benefit/cost ratio was more in plots receiving N,K fertilisers at 15, 75 and 120 DAP under sole as well as intercropped cassava.

Intercropping cassava with groundnut was found to be remunerative than sole cropping of cassava.

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* Originals not seen

Appendices

Appendix I

Weather data for the period from June, 1983 to April, 1984 (weekly average)

Standard weeks	Date	Rainfall (mm)	Temperature (°C) Maximum	Temperature (°C) Minimum	Relative humidity (%)
23	June 4 - June 10	7.05	33.4	25.15	92
24	June 11 - June 17	36.2	30.47	23.15	93.4
25	June 18 - June 24	18.4	30.47	23.8	95
26	June 25 - July 1	12.2	29.75	23.75	93.29
27	July 2 - July 8	4.5	31.16	24.6	93.14
28	July 9 - July 15	71.74	28.79	23.95	96.57
29	July 16 - July 22	53.48	27.7	22.67	96.7
30	July 23 - July 29	51.5	28.5	23.85	95.85
31	July 30 - Aug. 5	25.24	29.15	23.38	96.7
32	Aug. 6 - Aug. 12	37.04	27.8	23.49	96.71
33	Aug. 13 - Aug. 19	36.82	29.38	23.69	96.86
34	Aug. 20 - Aug. 26	18.0	28.1	24.46	96.5
35	Aug. 27 - Sep. 2	5.7	30.32	23.45	95.7
36	Sep. 3 - Sep. 9	9.5	29.64	23.7	95.5
37	Sep. 10 - Sep. 16	21.5	29.33	22.79	96.0
38	Sep. 17 - Sep. 23	23.78	28.08	23.17	97.6
39	Sep. 24 - Sep. 30	6.6	29.5	23.55	94.86
40	Oct. 1 - Oct. 7	8.57	29.6	22.69	94.43
41	Oct. 8 - Oct. 14	0.0	31.01	22.8	93.0
42	Oct. 15 - Oct. 21	4.1	30.75	23.29	90.29
43	Oct. 22 - Oct. 28	1.75	31.6	23.44	92.4
44	Oct. 29 - Nov. 4	8.2	31.44	23.47	91.8
45	Nov. 5 - Nov. 11	15.32	33.4	22.5	90.7
46	Nov. 12 - Nov. 18	1.86	31.47	20.69	82.14

(Contd........)

Appendix I Contd.......

Standard weeks	Date	Rainfall (mm)	Temperature (°C) Maximum	Temperature (°C) Minimum	Relative humidity (%)
47	Nov. 19 - Nov. 25	0.0	30.47	22.34	94.7
48	Nov. 26 - Dec. 2	0.0	30.75	23.36	77.28
49	Dec. 3 - Dec. 9	0.0	31.46	24.38	71.6
50	Dec. 10 - Dec. 16	0.0	28.79	24.02	74.9
51	Dec. 17 - Dec. 23	0.0	34.86	22.10	73.9
52	Dec. 24 - Dec. 31	3.09	33.59	23.02	95.12
1	Jan. 1 - Jan. 7	0.0	30.81	23.6	77.14
2	Jan. 8 - Jan. 14	0.0	30.13	23.4	72.13
3	Jan. 15 - Jan. 21	0.0	32.08	23.43	86.92
4	Jan. 22 - Jan. 28	0.0	32.7	20.7	74.0
5	Jan. 29 - Feb. 4	0.0	32.62	22.44	73.85
6	Feb. 5 - Feb. 11	0.0	32.46	24.9	77.4
7	Feb. 12 - Feb. 18	T	34.23	24.53	85.4
8	Feb. 19 - Feb. 25	4.41	34.92	23.46	92.43
9	Feb. 26 - Mar. 4	0.0	33.78	25.15	74.71
10	Mar. 5 - Mar. 11	1.17	31.29	23.75	92.14
11	Mar. 12 - Mar. 18	T	35.34	23.47	92.86
12	Mar. 19 - Mar. 25	0.0	36.84	23.36	92.57
13	Mar. 26 - Apr. 1	0.0	30.58	24.99	91.42
14	Apr. 2 - Apr. 8	2.03	33.7	24.34	91.85
15	Apr. 9 - Apr. 15	0.97	35.37	22.77	93.85
16	Apr. 16 - Apr. 22	3.16	33.25	24.2	83.24

Appendix II

Analysis of variance table for number leaves at different stages of growth of cassava

Source	df	Mean squares					
		Number of leaves per plant					
		30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
Total	47	..	..	..	..	..	..
Block	2	7.7	22.6	19.15	45.06	191.2	254.2
S	1	10.76	93.2	290.9	235.1	2.25	10.4
N	1	77.7	60.9	9.37	1383.3**	591.5**	873.1**
S x N	1	58.1	129.7	245.3	331.3	1.37	25.0
T	3	54.1	200.3	488.7	1491.5**	961.0**	827.5**
S x T	3	22.6	20.6	117.5	174.5	34.5	54.12
N x T	3	80.8	77.9	193.3	239.2	16.04	42.13
S x N x T	3	58.3	101.8	222.2	341.2	32.1	17.5
Error	30	52.6	70.8	192.1	263.8	23.6	45.18

* Significant at 5% level

** Significant at 1% level

Appendix III

Analysis of variance table for the height and girth of cassava at different stages of growth

Source	df	Mean squares									
		Height (cm)					Girth (cm)				
		30 DAP	60 DAP	90 DAP	120 DAP	Harvest	30 DAP	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..	..	..	..
Block	2	40.96	75.96	1559.6	6.37	1.62	0.4	1.87	0.81	0.03	0.056
System (s)	1	41.46	1.32	0.313	83.5	1323.0*	0.45	0.05	3.06	0.03	0.01
N	1	39.51	540.3**	543.5	17.87	5391.0**	0.06	0.04	6.05	0.12	0.27
S x N	1	58.77	0.031	22.18	1.50	722.0	0.05	0.19	2.01	0.15	0.003
T	3	36.61	1044.7**	1090.6**	541.4*	7219.6**	0.18	2.6	1.31	0.08	0.84**
S x T	3	64.63	25.05	195.6	33.9	461.3	0.33	1.08	1.08	0.03	0.18
N x T	3	47.61	14.98	86.19	55.5	320.8	0.32	1.31	0.57	0.10	0.23
S x N x T	3	50.77	85.8	198.5	9.20	1123.3**	0.42	0.59	1.07	0.02	0.56**
Error	30	21.45	37.07	187.3	181.3	218.3	0.28	1.23	1.10	0.08	0.085

* Significant at 5% level

** Significant at 1% level

Appendix IV

Analysis of variance table for canopy spread, LAI and NAR of cassava at different growth stages

Source	df	Canopy spread (cm)				LAI			NAR	
		30 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60-90 DAP	90-120 DAP
Total	47	..	..	..	..	..	..	..	..	..
Block	2	50.8	241.6	39.09	18.2	0.01	0.019	2.14	2.83	49.5*
System(s)	1	59.2	29.4	77.8	14.4	0.005	0.41**	0.27	2.23	0.73
N	1	6.51	483.1	7.68	11.18	0.17*	0.024	0.51	0.69	49.8*
S x N	1	65.3	8.39	11.0	0.46	0.0008	0.07*	2.12**	1.01	0.17
T	3	250.9*	726.7*	2.98	10.1	0.13**	0.38**	0.46	11.3**	9.06
S x T	3	20.9	122.1	6.39	6.49	0.05	0.07**	0.46	3.7*	12.7
N x T	3	27.9	134.4	20.7	13.7	0.15**	0.026	0.22	1.22	6.76
S x N x T	3	58.6	148.1	62.2	29.5*	0.35	0.22**	1.27	2.60*	6.39
Error	30	52.1	196.1	23.2	6.13	0.025	0.015	0.24	0.92	7.70

Mean squares

* Significant at 5% level

** Significant at 1% level

Appendix V

Analysis of variance table for yield attributes and yield oc cassava

Source	df	Mean squares					
		No. of tubers/ plant	Length of tubers/ plant (cm)	Girth of tubers/ plant (cm)	Tuber yield (t/ha)	Top yield (t/ha)	Utilisation index
Total	47	..	..	..	..	..	..
Block	2	4.79	13.6	0.76	0.10	23.4*	0.23*
System(s)	1	6.3*	129.7**	9.01*	17.6**	3.96	0.23*
N	1	4.5	16.2	16.1**	29.4**	0.39	0.20
S x N	1	0.79	6.5	6.59	13.6**	32.8**	0.33*
T	3	10.1**	60.0**	17.4**	55.1**	0.68	0.25**
S x T	3	0.77	9.01	4.55	8.49**	3.74	0.06
N x T	3	2.21	4.89	4.13	4.62**	10.56	0.11
S x N x T	3	0.9	25.5	0.69	2.03	26.39**	0.25**
Error	30	1.44	12.7	1.82	0.68	4.87	0.053

* Significant at 5% level

** Significant at 1% level

Appendix VI

Analysis of varience table table for drymatter, starch, crude protein and HCN content of cassava tuber

Source	df	Mean squares			
		Drymatter content (%)	Starch content (%)	Crude protein content (%)	HCN content (mg/kg)
Total	47	..	..	..	..
Block	2	15.7	38.1*	0.25	1217.6
System(s)	1	77.9	135.9**	0.43	7.19
N	1	0.27	64.5**	0.94*	490.9
S x N	1	22.6	120.0**	0.35	4379.5**
T	3	16.9	62.3**	1.63**	436.8
S x T	3	42.8	6.64	0.21	725.7
N x T	3	39.2	2.58	0.12	3278.1**
S x N x T	3	25.4	1.47	0.28	1973.8**
Error	30	30.8	5.28	0.15	355.2

* Significant at 5% level

** Significant at 1% level

Appendix VII

Analysis variance table for height, LAI, pod yield and bhusa yield of groundnut

Source	df	Mean squares						
		Height		LAI		Pod yield (kg/ha)	Bhusa yield (t/ha)	LER
		45 DAP	90 DAP	45 DAP	90 DAP			
Total	23	..	..	..	..	..	..	..
Block	2	11.21*	2.93	0.63	0.93	6500.3	0.437	0.002
N	1	1.19	12.89	0.18	0.007	73269.7**	0.385	0.048
T	3	15.32*	19.89**	0.03	0.17	84355.1**	0.648	0.006
N x T	3	5.97	10.92	0.014	0.146	37372.30	0.101	0.0034
Error	14	2.2	4.44	0.137	0.188	13758.3	0.259	0.008

* Significant at 5% level

** Significant at 1% level

Appendix VIII

Analysis of variance table for leaf and petiole N content of cassava at different stages of growth

Source	df	Mean squares							
		Leaf N content (%)				Petiole N content (%)			
		60 DAP	90 DAP	120 DAP	Harvest	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..	..
Block	2	0.19	0.50	0.20	0.425	0.13	0.02	0.016	0.024
S	1	0.004	0.003	0.26	0.0079	0.009	0.009	0.059	0.0021
N	1	0.39	0.145	1.17	3.65**	0.34*	0.0093	0.0005	0.27
S x N	1	1.21*	0.73	2.26*	1.18*	0.07	0.039	0.017	0.0018
T	3	1.16**	0.63	0.16	3.26**	0.012	0.047	0.045	0.169
S x T	3	0.46	0.109	0.29	0.34	0.035	0.082	0.056*	0.106
N x T	3	0.84	0.119	0.23	0.93	0.106	0.012	0.009	0.113
S x N x T	3	0.16*	0.198	0.22	0.53*	0.08	0.0036	0.019	0.069
Error	30	0.21	0.128	0.31	0.21	0.05	0.033	0.018	0.026

* Significant at 5% level

** Significant at 1% level

Appendix IX

Analysis of variance table for stem and tuber N content of cassava at different stages of growth

Source	df	Mean squares						
		Stem N content (%)				Tuber N content (%)		
		60 DAP	90 DAP	120 DAP	Harvest	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..
Block	2	0.005	0.003	0.001	0.012	0.031	0.002	0.0057
S	1	0.0016	0.014	0.075**	0.016	0.128**	0.028**	0.015
N	1	0.023	0.00005	0.001	0.124**	0.0002	0.000019	0.024*
S x N	1	0.001	0.003	0.00013	0.0008	0.0012	0.00075	0.0088
T	3	0.024	0.031	0.21**	0.14**	0.017	0.0034	0.043**
S x T	3	0.033	0.016	0.012	0.011	0.004	0.0004	0.0058
N x T	3	0.0023	0.043	0.003	0.0017	0.009	0.009	0.0040
S x N x T	3	0.086	0.039	0.01	0.00048	0.023	0.013	0.0082
Error	30	0.024	0.013	0.004	0.0039	0.008	0.0038	0.0038

* Significant at 5% level

** Significant at 1% level

Appendix X

Analysis of variance table for leaf and petiole P content of cassava at different stages of growth

Source	df	Mean squares							
		Leaf P content (%)				Petiole P content (%)			
		60 DAP	90 DAP	120 DAP	Harvest	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..	..
Block	2	0.002	0.00048	0.00013	0.00046	0.0066	0.0012	0.0015	0.00078
S	1	0.008	0.00021	0.00017	0.00035	0.00059	0.0089	0.018**	0.00017
N	1	0.014	0.0017*	0.00005	0.00035	0.0065	0.0012	0.0075	0.000019
S x N	1	0.0098	0.00082	0.000002	0.00005	0.0028	0.000003	0.012*	0.00047
T	3	0.010	0.00051*	0.00043	0.00061	0.002	0.0015	0.0013	0.00054
S x T	3	0.0014	0.0011	0.00068	0.00011	0.0082	0.00057	0.0027	0.00037
N x T	3	0.004	0.00062	0.00034	0.0002	0.0034	0.0016	0.0003	0.00052
S x N x T	3	0.0029	0.00036	0.00087	0.00015	0.0094	0.00039	0.0016	0.0013**
Error	30	0.0019	0.00032	0.00044	0.00053	0.001	0.00053	0.0021	0.00019

* Significant at 5% level

** Significant at 1% level

Appendix XI

Analysis of variance table for stem and tuber P content of cassava at different stages of growth

Source	df	Mean squares						
		Stem P content (%)				Tuber P content (%)		
		60 DAP	90 DAP	120 DAP	Harvest	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..
Block	2	0.002	0.00011	0.0015	0.00083*	0.00059	0.0038	0.0002
S	1	0.0017	0.00017	0.001	0.00025	0.00051	0.000008	0.000002
N	1	0.0013	0.00011	0.0016	0.000002	0.00061	0.000008	0.000018
S x N	1	0.001	0.00017	0.001	0.00075*	0.0012	0.000003	0.00025
T	3	0.0013	0.000028	0.0014	0.00019	0.00079	0.0007	0.000002
S x T	3	0.0019	0.0031**	0.0004	0.00034	0.00015	0.0005	0.00016
N x T	3	0.0018	0.000097	0.00009	0.00021	0.00008	0.0011	0.000029
S x N x T	3	0.0018	0.002*	0.0004	0.00021	0.00043	0.000095	0.000052
Error	30	0.0011	0.00065	0.0005	0.00018	0.00024	0.00053	0.000067

* Significant at 5% level

** Significant at 1% level

Appendix XII

Analysis of variance table for leaf and petiole K content of cassava at different growth stages

Source	df	Mean squares							
		Leaf K content (%)				Petiole K content (%)			
		60 DAP	90 DAP	120 DAP	Harvest	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..	..
Bloack	2	0.15	0.31	0.013	0.0109	0.34	0.52*	0.028	0.548**
S	1	0.034	0.28	0.216**	0.246**	0.07	0.33	0.367	0.259
N	1	0.039	0.021	0.0034	0.285**	1.04*	1.33	0.035	1.33**
S x N	1	0.19	0.075	0.028	0.015	0.55	0.021	0.414	0.0054
T	3	0.047	0.059	0.012	0.021	0.80*	0.20	0.041	0.141
S x T	3	0.037	0.069	0.027	0.108*	0.18	0.29	0.033	0.065
N x T	3	0.007	0.022	0.029	0.0079	0.66	0.082	0.045	0.097
S x N x T	3	0.060	0.029	0.06	0.042	0.02	0.21	0.016	0.049
Error	30	0.053	0.032	0.022	0.032	0.25	0.089	0.112	0.078

* Significant at 5% level

** Significant at 1% level

Appendix XIII

Analysis of varience table for stem and tuber K content of cassava at different stages of growth

Source	df	Mean squares						
		Stem K content (%)				Tuber K content (%)		
		60 DAP	90 DAP	120 DAP	Harvest	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..
Block	2	0.079	0.21	0.24	0.0067	0.0039	1.01	0.018
S	1	0.25	0.39**	0.00038	0.0015	0.027	1.05	0.0075
N	1	0.13	0.027	0.080	0.011	0.015	2.0	0.00021
S x N	1	0.026	0.43**	0.056	0.032*	0.009	0.013	0.042
T	3	0.023	0.159	0.0084	0.085**	0.62**	0.20	0.079
S x T	3	0.007	0.026	0.043	0.014	0.027	0.075	0.013
N x T	3	0.038	0.014	0.0025	0.019*	0.035	0.090	0.0175
S x N x T	3	0.29	0.039	0.031	0.033**	0.019	0.108	0.033
Error	30	0.079	0.059	0.040	0.005	0.02	0.109	0.0313

* Significant at 5% level

** Significant at 1% level

Appendix XIV

Analysis of varience table for N and P uptake by cassava at different stages of growth

Source	df	N uptake (kg/ha)				P uptake (kg/ha)			
		60 DAP	90 DAP	120 DAP	Harvest	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..	..	..	..
Block	2	75334	177976	5366848*	842272	337.4	1754.3	82916	51566.8**
S	1	59632	775328**	206208	2420832	6.31	2640.7	74082	137615
N	1	263428*	516704*	7991232**	656416	247.3	1762.5	141041*	2832
S x N	1	78248	90064	11200	333056	188.3	43.88	1.0	30613.5*
T	3	851054**	1544704**	930944	11905483	1807.3*	4850.5*	20784	30330.5**
S x T	3	52760	100747	1633450	524224	450.7	238.5	73090	6943.0
N x T	3	241665*	228955	39637.3	458901	333.0	681.29	46757	3315.6
S x N x T	3	19288	226027	553488.1	256928	676.5	1542.5	16349.6	5880.8
Error	30	53739.8	96119	799716	477261	328.7	1234.5	20877.9	5655.5

* Significant at 5% level

** Significant at 1% level

Appendix XV

Analysis of variance table for K uptake by cassava at different stages of growth

Source	df	Mean squares			
		K uptake (kg/ha)			
		60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..
Block	2	65564	243632	8858624*	5872576*
S	1	42624	1770624**	3092352	1421568**
N	1	20136	1124256*	17104896**	4291200
S x N	1	40016	229888	266496	717824
T	3	97589*	3544160**	6176043**	27191680**
S x T	3	26843	662954*	7552896**	4476245*
N x T	3	35667	109290	2650880	4183296*
S x N x T	3	19252	848458**	1462656	1828821*
Error	30	24027	151185	1140122	1342545

* Significant at 5% level

** Significant at 1% level

Appendix XVI

Analysis of variance table for N P K content and uptake of bhusa of groundnut

Source	df	Mean squares					
		N content of bhusa (%)	P content of bhusa (%)	K content of bhusa (%)	N uptake by bhusa (kg/ha)	P uptake of bhusa (kg/ha)	K uptake of bhusa (kg/ha)
Total	23	..	..	..	..	..	..
Block	2	0.058	0.0005	0.0001	66.69	0.194	3.37
N	1	0.014	0.0	0.007	71.21	0.109	0.26
T	3	0.033	0.0	0.004	59.76	0.149	2.13
N x T	3	0.045	0.0006	0.021	58.25	0.175	25.67**
Error	14	0.028	0.00025	0.007	38.31	0.05	5.78

* Significant at 5% level

** Significant at 1% level

Appendix XVII

Analysis of variance table for soil N and P content at different growth stages

Source	df	Mean squares				
		N content of soil (kg/ha)				
		30 DAP	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..
Block	2	21040	296240	220912	267952	59248
S	1	1484032**	396032*	1104160**	2294912*	598528**
N	1	1872304**	320160	00	255216	43200
S x N	1	1116304**	58784	00	255184	76800
T	3	4724570**	376544**	693621**	485605	1506421**
S x T	3	15745600**	39296	48992	301877	88693
N x T	3	1000560**	176288	68608	263392	168640
S x N x T	3	1400373**	151392	33749	468272	141259
Error	30	141806	76921	54526	322294	60541.8

* Significant at 5% level

** Significant at 1% level

(Contd....)

Appendix XVII Contd........

Source	df	Mean squares				
		P content of soil (kg/ha)				
		30 DAP	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..
Block	2	1346.7	506.3	560.5	267.4	724.6
S	1	1618.1	1794.7	4781.4*	571.8	339.9
N	1	393.1	3125.0*	389.1	162.7	585.8
S x N	1	96.3	760.0	408.1	2486.6	121.1
T	3	419.7	594.5	694.7	1796.4	1201.8**
S x T	3	409.9	1163.7	309.8	420.9	305.2
N x T	3	745.3	256,2	203.9	673,3	245.6
S x N x T	3	59.5	68.06	408.9	653.7	373.5
Error	30	391.04	472.3	723.3	684.6	248.6

* Significant at 5% level

** Significant at 1% level

Appendix XVIII

Analysis of variance table for K content of soil at different stages

Source	df	Mean squares				
		K content of soil (kg/ha)				
		30 DAP	60 DAP	90 DAP	120 DAP	Harvest
Total	47	..	..	..	..	..
Block	2	202.5	1827	37323	2753.5	13016.0
S	1	1519	15768*	16080	2276.0	15408.0
N	1	17252*	15052*	416.0	7765.0	3008.0
S x N	1	7253	13004*	243472**	8281.0	9636.0
T	1	56907**	4513.3	97875*	26814.0	13973.0
S x T	3	3996.7	5802.7	15247.3	7429.0	10669.3
N x T	3	3996.7	8708.0*	25636.7	7313.6	3725.3
S x N x T	3	4240.3	1422.7	3920.0	6766.0	3794.6
Error	30	2866.5	2709.3	22289.2	9695.6	7283.2

* Significant at 5% level

** Significant at 1% level

FERTILISER MANAGEMENT IN CASSAVA - GROUNDNUT INTERCROPPING SYSTEM

By

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ABSTRACT OF THE THESIS

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ABSTRACT

An experiment was conducted at Agricultural Research Station, Mannuthy, to study the effect of levels of N and time of application of N and K in a cassava-groundnut intercropping system. This 2 x 2 x 4 factorial experiment was laid out in Randomised Block Design with three replications under rainfed conditions.

The study revealed that intercropping cassava with groundnut enhanced the growth parameters of cassava at all stages of growth. Yield attributes, yield and total drymatter production of cassava were also increased by intercropping. The quality characters like drymatter, starch and crude protein content of tubers were improved by intercropping. Hundred per cent recommended dose of N increased the growth, yield and quality over 75 per cent of the recommended dose.

Among the time of application T_3 (15, 75 and 120 DAP) has given the highest tuber yield (21.92 t ha^{-1}) followed by T_1 (15, 60 and 90 DAP) of 21.65 t ha^{-1}. T_4 (basal, 60 and 90 DAP) which is the recommended dose recorded the lowest yield of 17.9 t ha^{-1}.

A comparatively higher utilisation index was obtained with intercropping and higher levels of N (75 kg ha^{-1}). T_1 and T_3 recorded more UI values than T_2 and T_4.

The nutrient content as well as uptake in cassava was increased by legume intercropping and higher levels of N.

T_1 and T_3 recorded more nutrient content in different plant parts as compared to T_2 and T_4.

The fertility status of the soil was improved by intercropping and levels of N.

Yield of groundnut was influenced by higher levels of N and time of application of N and K to cassava. T_2 and T_4 recorded more yield. Nutrient content and uptake of bhusa was not influenced by levels of N and time of application of N and K.

Maximum LER was seen in sole cassava plot when N and K was given at 15, 75 and 120 DAP while in intercropped plot it was highest when N and K were given at 15, 60 and 90 DAP.

Income from cassava cultivation was increased by intercropping with groundnut and application of N and K at 15, 75 and 120 DAP.

Groundnut can be intercropped successfully with cassava under Kerala condition and a substantial quantity (25 per cent) of fertiliser nitrogen required by the main crop could be saved by this practice. For getting better fertiliser use efficiency of applied N and K fertilisers, 1st dose should be applied at 15 DAP of cassava instead of the now recommended basal dose. Second dose can be extended upto 75 days of planting and the last dose upto 120 DAP so as to coincide with the harvest of the intercrop and the earthing up of cassava.